SAINT CROIX RIVER BASIN
Baileyville, Maine, United States and St. Stephen, New Brunswick, Canada

WOODLAND DAM
ME 00218

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
Waltham, Mass. 02154

SEPTEMBER 1981

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

407-102

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ME 00218	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Woodland Dam NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS		5. TYPE OF REPORT & PERIOD COVERED INSPECTION REPORT 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEPT. OF THE ARMY, CORPS OF ENGINEERS NEW ENGLAND DIVISION, NEDED 424 TRAPELO ROAD, WALTHAM, MA. 02254		12. REPORT DATE September 1981 13. NUMBER OF PAGES 60
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVAL FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Saint Croix River Basin
Baileyville, Maine, US and St. Stephen, New Brunswick, Canada
St. Croix River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The overall length of the dam and spillways is about 1910 ft. with a maximum height of about 39 ft. The dam is generally in fair condition. There were no signs of impending structural failure or other conditions which would warrent urgent remedial attention. It is intermediate in size with a hazard classification of high. There are various remedial measures which should be undertaken by the owner to assure the continued performance of the dam.

FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SAINT CROIX RIVER BASIN
Baileyville, Maine, United States and
St. Stephen, New Brunswick, Canada

[WOODLAND DAM, Baileyville, Maine...]
ME 00218

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
Waltham, Mass. 02154

SEPTEMBER 1981

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

Identification No.:	ME 00218	
Name of Dam:	Woodland Dam	
Country:	United States	Canada
Town:	Baileyville	St. Stephen
County, State (U.S.A.): Province (Canada):	Washington, Maine	New Brunswick
Stream:	St. Croix River	
Date of Inspection:	11 August 1981	

BRIEF ASSESSMENT

Woodland Dam is a run of the river concrete gravity hydropower structure constructed in 1905. The dam consists of several features including a powerhouse and headworks, emergency spillway, principal spillway, process water intake and fishway. The overall length of the dam and spillways is about 1910 feet. The dam is about 39 feet high.

The dam is generally in fair condition. There were no signs of impending structural failure or other conditions which would warrant urgent remedial action, although several deficiencies regarding the hydraulic wall, headworks and adjacent wingwall, and guide wall downstream from the left abutment were noted which will require remedial action.

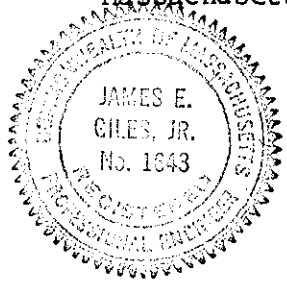
Based on a maximum storage of 4380 acre-feet the project falls within the intermediate size classification. The dam's hazard classification has been established as "high". A failure would seriously damage the paper mill immediately downstream, which is manned around the clock, with water depths ranging up to 16 ft. The test flood used for this structure is the Probable Maximum Flood. The estimated peak inflow for the PMF is 46,200 cfs which is equal to the peak routed outflow. This outflow corresponds to a reservoir level of El. 140.0 which is below the crest El. 142.21 and no overtopping would occur.

Georgia-Pacific Corp., the owner of the dam should engage the services of a registered professional engineer to: investigate the structural integrity of the hydraulic wall, headworks and adjacent wingwall and left abutment guidewall; prepare a complete set of site drawings; investigate the sedimentation; and investigate an alternative to the floating walkway. Other remedial measures include expanding the existing emergency evacuation system to include Woodland Dam, repair the

concrete on the spillways and powerhouse, prepare an operations and maintenance manual, conduct annual technical inspections, and compile all available plans on the site.

The above measures as outlined in Sections 7.2 and 7.3 should be implemented at the next reservoir drawdown or within one year of receipt of this report.

J.E. Giles, Jr., P.E.
Project Manager
Massachusetts Registration No. 1643



CORPS OF ENGINEERS

SIGNATURE PAGE

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety inspection of Dams, for Phase I investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of Phase I investigation: however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

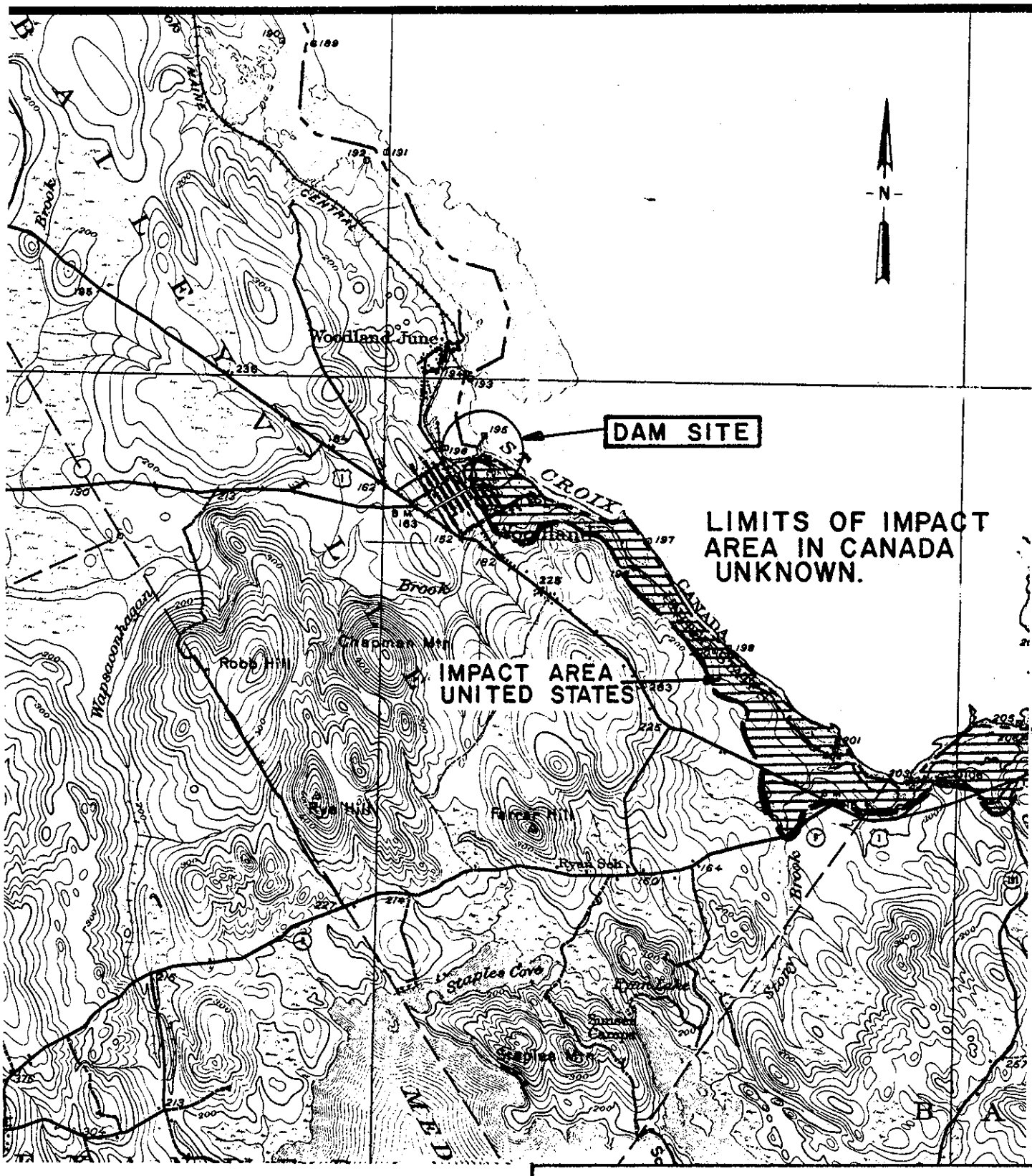
It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The Phase I Investigation does <u>not</u> include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project compliance with OSHA rules and regulations is also excluded.

TABLE OF CONTENTS

1. Overview of dam from left abutment



FROM: USGS CALAIS, ME.
15 MIN. QUADRANGLE MAP

MAINE
Vicinity Map

0
SCALE: 1" = 1 MILE

WOODLAND DAM
LOCATION MAP

U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM

DATE SEPT. 1981

MAIN

CLIENT	JOB	PLATE
1345	72	

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT

WOODLAND DAM
BAILEYVILLE, MAINE, UNITED STATES
ST. STEPHEN, NEW BRUNSWICK, CANADA

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority - Public Law 92-367, August 8, 1972 authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Chas. T. Main, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Maine. Authorization and notice to proceed were issued to Chas. T. Main, Inc. under a letter of November 6, 1979 from Max B. Scheider, Colonel, Corps of Engineers. Contract No. DACW 33-80-C-0011 has been assigned by the Corps of Engineers for this work.

b. Purpose - The purposes of the inspection program are:

(1) To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner of non-Federal interests.

(2) To encourage and prepare the states to initiate effective dam safety programs for non-Federal dams.

(3) To update, verify and complete the National Inventory of Dams.

c. Scope of Inspection Program - The scope of this Phase I inspection report includes:

(1) Gathering, reviewing and presenting all available data as can be obtained from the owners, previous owners, the state and other associated parties.

(2) A field inspection of the facility detailing the visual condition of the dam embankments and appurtenant structures.

(3) Computations concerning the hydraulics and hydrology of the facility and its relationship to the calculated flood through the existing spillway.

(4) An assessment of the condition of the facility and corrective measures required.

It should be noted that this report does not pass judgment on the safety or stability of the dam other than on a visual basis. The inspection is to identify those features of the dam which need corrective action and/or further study.

1.2 Description of Project

a. Location - Woodland Dam is located on the St. Croix River in the community of Woodland in the town of Baileyville, Washington County, Maine. The international boundary between Canada and the United States is located on the emergency spillway about 100 ft. left of the corner pier. That portion of the dam in Canada is located in the town of St. Stephen, New Brunswick. The latitude and longitude of the dam site are N 45°09'34" and W 67°24'12".

b. Description of Dam and Appurtenances - The project is a run of the river hydro power structure, which also serves as a process water supply source for the Georgia-Pacific Corp. paper mill just downstream. The dam is a concrete gravity structure, founded on bedrock, which includes a powerhouse and headworks, emergency spillway, principal spillway, process water intake and fishway. The overall length of the dam and spillways is about 1910 feet. The dam's height is about 39 feet.

The non-overflow section on the right abutment (American Side) is referred to as the hydraulic wall. The wall is about 795 feet long, with a maximum height of 37 feet and a crest width of 5' at El. 141. The upstream slope has a batter of 5 inches per foot from El. 136.4 to El. 125.0 which changes to 8 inches per foot to El. 115.0 and 9 inches per foot to the toe. The downstream slope has a batter of 1 inch per foot.

Left of the hydraulic wall is the headworks and the powerhouse. There are seven units in the powerhouse. 4 - 1700 HP (1200 kW) S. Morgan Smith, twin horizontal Francis turbines and 3 - 1100 HP (750 kW) Hercules, twin horizontal Francis turbines. The flow to the three smaller units (4,506) is controlled by 6 - 4 foot wide timber sluice gates at invert El. 120.0. Flow to the four larger units is through two openings. Each opening supplies flow to two units and is controlled by 4 - 4 foot wide timber gates at invert El. 120.0. All of the sluice gates are hand operated from the crest of the headworks and all are fitted with trashracks. The crest of the headworks is tri-level with a 3 foot wide strip on the front face raised 6" to El. 141.0 and a 12" wide curb on the rear face elevated 12" to El. 141.5.

Adjacent to the headworks is a small wing wall 30 feet long which includes the intake to the process water supply and the

fishway. The process water is conveyed through a 42" Ø steel penstock which is controlled by an 84" screw operated timber sluice gate at invert El. 116. There is a small gatehouse for this gate. The intake to the fishway is located adjacent to the gatehouse and is controlled by a 48" screw operated timber sluice gate.

The principal spillway is a concrete gravity sharp crested weir section which is controlled by 5-6' x 12.5' tainter gates. The gates are hand operated from a catwalk over the spillway.

The emergency spillway is a concrete gravity sharp crested weir section. There are two sections to the structure. The Canadian section runs from the left abutment (Crest El. 142.21) 583'3" across the river to a corner pier (Crest El. 142.21). This section has a crest width of 7'6" at El. 134.21. The upstream slope has a batter of 1 inch per foot, and the downstream slope has a batter of 9 inches per foot from El. 130 to the toe. The American section runs from the corner pier to the principal spillway a distance of about 200 feet. The angle at the downstream corner of the pier between the two sections is $109^{\circ}30'$. The American section has a crest width of 6 feet at El. 136.0. The upstream face is vertical and the downstream slope from El. 127.96 to the toe has a batter of 9 inches per foot. Each of the two sections is equipped with flashboards which raise the crest elevation to 141'. The flashboards are supported by bolted wooden brackets placed 4'0" on center. Flashboards are removed by hand from a floating log walkway in front of the two sections which is held in place by cables from 4 piers located upstream of the emergency spillway.

About 250 feet left of the corner pier on the downstream side of the Canadian section there is a low concrete training wall. It is approximately 180 feet long and 15 feet wide, and splits the emergency spillway flow to either side of an island in the downstream channel.

There are also three logbooms upstream of the structures. The first is located about 50 yards in front of the headworks. The second spans the river about 150 yards upstream of the emergency spillway and the third boom spans the river about 300 yards upstream of the dam.

c. Size Classification - The storage to the top of Woodland Dam is estimated to be 4,380 ac. ft. and the hydraulic height 39 feet. Storage of from 1,000 to 50,000 acre feet and/or a height of from 40 to 100 ft. classifies this dam in the intermediate size category.

d. Hazard Classification - Woodland Dam is classified as having a high hazard potential. Dam failure analysis computations are included in Appendix D, which are based on "Guidance for

Estimating Downstream Dam Failure Hydrographs". Failure of the dam would seriously damage the powerhouse and paper mill plant immediately downstream with water depths ranging up to 16 feet. These facilities are manned 24 hours a day and more than a few lives could be lost in the event of failure.

e. Ownership - The name, address and phone number of the current owner of Woodland Dam is:

Georgia-Pacific Corporation
Woodland, Maine
Phone: (207) 427-3311

Georgia-Pacific Corp. acquired the site from St. Croix Paper Company in 1963 who had owned the dam since its construction in 1906.

f. Operator - Mr. Michael G. Lambert, Plant Engineer is responsible for the operation and maintenance of the dam. He is located at the site and his phone number is (207) 427-3311.

g. Purpose - Since its construction, the dam has produced hydropower to run a paper mill at the present site. As part of the paper process originally it also powered a grinder room, where generators have since been installed. It has also served as a process water supply source for the paper mill.

h. Design and Construction History - The dam was constructed in 1906 for the St. Croix Paper Company. Two design drawings (see Appendix B) dated June 17, and February 20, 1905 shows that the dam was originally designed by George F. Hardy, Architect & Engineer, 309 Broadway, New York, New York. A drawing dated January 24, 1951 entitled gravity wall design is also included in Appendix B. It is unknown what significance this sheet had in the history of the site. In 1943, the dam received a gunite surface treatment. It is unknown to what extent the treatment was given. In 1953 the crest of the headworks was replaced. Georgia-Pacific Corp. acquired the site in 1963. Also in that year the fishway was constructed to its present day configuration. In 1965, the 42" Ø steel process water penstock and the control structure were added at the site of the old logway. It is not known when, but the crest of the hydraulic wall was resurfaced by Georgia-Pacific Corp.

Georgia-Pacific Corp. initiated a major rehabilitation project at the site in 1972. The project included the resurfacing of the crest and downstream face of the emergency spillway, a new floating walkway and a new flashboard structure. although not originally planned, the remainder of the emergency spillway and the principal spillway were added to the contract and repaired identically. In addition the tainter gates were added to the principal spillway. These repairs were designed by Neill & Gunter Limited, and were constructed by Atlas

Construction Mairitimes Limited, P.O. Box 7, Doak Rd., Fredericton, New Brunswick.

i. Normal Operational Procedures - A hydro-power procedure for regulation of Woodland Dam & Power Station is included in Appendix B. Basically, there are two regulations pertinent to the operation of the control structures of the dam;

1. Maintain minimum flow of 750 cfs in St. Croix River;

2. Woodland Dam will be notified by Grand Falls Dam, which is located 17 miles upstream of Woodland, when a gate is opened or closed.

As evidenced by the second regulation,the governing factor for operation of the Woodland Dam is the discharge from Grand Falls Dam. The estimated travel time for discharge from Grand Falls to Woodland is approximately 4 hours. Basically, Woodland is operated to discharge whatever Grand Falls Dam is discharging. The normal operating range of the Woodland pool is 2 feet with a maximum allowable elevation 141'4".

The dam and power station are manned round the clock. Rain gauge readings and storage readings are made on a daily basis and shortened to hourly readings during high flow conditions. Flood flows are handled on a step basis. When the flow thru the turbines cannot maintain a level of 141'4" the tainter gates are operated, when flow exceeds the principal spillway capacity removal begins of the flashboards.

1.3 Pertinent Data

The datum for the elevations to be used is not noted on the drawings however it is in very close agreement with the National Geotetic Vertical Datum elevations from the Calais, Maine Geological Survey Sheet.

a. Drainage Area - The drainage area tributary to the site is 1350 square miles. Georgia-Pacific Corp. owns, operates and maintains a series of structures (see Appendix B.) in the drainage area which control all but approximately 30 square miles below Grand Falls Dam. The entire area could be considered a wilderness area with a few rural communities scattered across the basin. For hydrologic computations the basin was considered as flat, coastal terrain.

b. Discharge at Damsite

(1) Outlet Works - Three openings to the turbines are each controlled by 4' wide timber sluice gates at invert El. 120.0 with a combined discharge capacity of 3,000 cfs. The principal spillway crest is at El. 136.0 and is equipped with 5 - 6' x 12.5' tainter gates. The emergency spillway is at two levels. El. 136.0 on the American side and El. 134.21 on

the Canadian spillway. Each is equipped with flashboards which bring the crest to El. 141'. The 42" Ø process water penstock is controlled by an 84" screw operated timber sluice gate at invert El. 116.0. The fishway is controlled by a 48" screw operated timber sluice gate.

(2) Maximum known flood - 23,300 cfs on May 1923.

(3) Principal spillway capacity at top of dam - 3,600 cfs @ El. 142.21

(4) Principal spillway capacity at emergency spillway crest elevation - 2600 cfs @ El. 141.0.

(5) Gated spillway capacity at normal pond elevation - 2,050 cfs @ El. 140.3

(6) Gated spillway capacity at test flood elevation - 1,900 cfs @ El. 140.0.

(7) Emergency spillway capacity at test flood elevation- 44,000 cfs at El. 140.0.

(8) Total project discharge at top of dam - 70,500 cfs at 142.21.

(9) Total project discharge at test flood elevation - 46,100 cfs @ El. 140.0.

c. Elevations

(1)	Streambed at toe of dam	103
(2)	Bottom of cutoff	N/A
(3)	Maximum tailwater (Design)	94.0
(4)	Normal pool	140'4"
(5)	Full flood control pool	N/A
(6)	Principal spillway crest	
	a. Ungated	136
	b. Gated	142
(7)	Emergency spillway crest	
	a. Ungated - Canadian Section	134.21
	- American Section	136.0
	b. Gated	141.0

(8)	Design surcharge (Original Design)	Unknown
(9)	Top of dam	142.21
(10)	Test flood surcharge	140.0

d. Reservoir (Length in feet)

(1)	Normal Pool	8,500
(2)	Flood control pool	N/A
(3)	Spillway crest pool	
	a. Ungated emergency	7,300
	b. Ungated principal	7,500
	c. Gated emergency	8,700
	d. Gated principal	8,900
(4)	Top of dam	9,000
(5)	Test flood pool	8,200

e. Storage (acre-feet)

(1)	Normal pool	2,000
(2)	Flood control pool	N/A
(3)	Spillway crest pool	
	a. Ungated emergency	200
	b. Ungated principal	400
	c. Gated emergency	2,600
	d. Gated principal	4,000
(4)	Test flood pool	1,800
(5)	Top of dam	4,380

f. Reservoir Surface (acres)

(1)	Normal pool	800
(2)	Flood-control pool	N/A
(3)	Spillway crest pool	

a.	Ungated emergency	500
b.	Ungated principal	600
c.	Gated emergency	850
d.	Gated principal	900
(4)	Test flood pool	790
(5)	Top of dam	910

g. Dam

(1)	Type	Concrete gravity
(2)	Length	795 feet
(3)	Height	39 feet
(4)	Top Width	5 feet
(5)	Side Slopes	Upstream 5 in./ft. from El. 136.4 to 125.0, 8 in./ft. to El. 115.0 and 9 in./ft. to toe downstream 1 in./ft.
(6)	Zoning	N/A
(7)	Impervious Core	N/A
(8)	Cutoff	None
(9)	Grout curtain	None
(10)	Other	N/A

h. Diversion and Regulating Tunnel

i. Spillway (Principal)

(1)	Type	Concrete sharp crested weir
(2)	Length of weir	62.5 feet
(3)	Crest elevation	
a.	Ungated	136.0
b.	Gated	142.0

(4) Gates		5 - 6' x 12.5' tainter
(5) U/S Channel		Reservoir
(6) D/S Channel		Exposed bedrock
(7) General		N/A

Spillway (Emergency)

	Canadian Section	American Section
(1) Type	Concrete sharp crested weir	
(2) Length of Weir	583'3"	198'
(3) Crest elevation		
a. Gated	141	141
b. Ungated	134.21	136.0
(4) Gates	Flashboards	Flashboards
(5) U/S Channel	Reservoir	Reservoir
(6) D/S Channel	Exposed bedrock	Exposed bedrock
(7) General	Training wall midway at the toe	N/A

j. Regulating Outlets

(1) Description	14 timber sluice gates to turbines
(2) Size	4' wide
(3) Invert	120
(4) Control Mechanism	Cog and wheel hand operated lifting device
(5) Other	N/A

SECTION 2

ENGINEERING DATA

2.1 Design Data

Two design drawings for the original construction of Woodland Dam were obtained from the files of Georgia-Pacific. One plan is a cross section thru the generator and pump rooms, dated June 17, 1905. The second is a plan view and cross sections of the Canadian spillway, American spillway and hydraulic wall dated February 20, 1905. A drawing dated January 24, 1951 entitled "Gravity Wall Design" was also obtained from the files of Georgia-Pacific but the purpose of this drawing is unknown. A prior inspection report of Woodland and Grand Falls dams prepared by Chas. T. Main, Inc. dated December 2, 1958 was also reviewed and is included in Appendix B. It is noted in the report that it was a supplement to a previous inspection report dated December 1953. This report could not be located. Several design drawings by Neill and Gunter Limited, Fredricton, New Brunswick, for the 1972 rehabilitation of the Canadian spillway were obtained and are included in Appendix B. These documents comprise all the design data available at the time of the inspection.

2.2 Construction Data

Three as built drawings for the 1972 rehabilitation of the Canadian Spillway were reviewed.

2.3 Operation Data

Records concerning the day to day operation of the Woodland Dam have been recorded since 1916. This data is available in the files of the Engineering Dept. for Georgia-Pacific at Woodland Dam. In addition, formal operation procedures for the normal operation of the dam and powerhouse were reviewed and are included in Appendix "B". It was noted that when operation of the powerhouse cannot maintain the reservoir level below the allowable maximum of 141' 4", control of the dam and its appurtanent structures is handled directly by the Engineering Staff at the site.

Annual technical inspections of the site are conducted by the Power and Utilities Area Engineer for Georgia- Pacific. Copies of these reports are available in the files of Georgia-Pacific at the site.

A Georgia-Pacific Corp. intracompany memo concerning emergency operation procedures for three of their upstream structures is also included in Appendix B. Although the procedure does not include action relative to Woodland, it can be easily expanded to include Woodland Dam.

2.4 Evaluation of Data

a. Availability - Copies of the design and construction drawings available for use in preparing this report are included in Appendix B. Generally the number of drawings available for the amount of work which has been done on this dam must be considered inadequate. No single complete set of drawings for any of the repairs noted were available.

b. Adequacy - The lack of design calculations did not allow for a definitive review. Evaluation was based on visual inspection, past performance history, and sound engineering judgement and experience.

c. Validity - The limited design data available restrict evaluation of the Woodland Dam and its appurtenances to the visual inspection and engineering judgement.

SECTION 3

VISUAL EXAMINATION

3.1 Findings

a. General - The Phase I visual examination of Woodland Dam was conducted on 11 August 1981. The upstream water surface elevation that day was approximately El. 140.

In general the project was found to be in fair condition. Deficiencies regarding the left abutment, the hydraulic wall, the headworks and the adjacent wing wall were noted.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C.

b. Dam - The non-overflow portion of the project consists of the hydraulic wall, the headworks and the adjacent wing wall, and the left abutment.

The hydraulic wall is generally in fair condition. The crest of the wall appears to have been recently repaired. The old mill downstream of the wall is presently being destroyed. Near the crest, it is difficult to distinguish between the downstream face and the old wall. (See Photos 12 and 13). Seepage was noted as a wetness along most of the old lift lines. Extensive spalling varying in depths from 1/4" to 6-8" and several longitudinal hairline cracks 40 to 50 ft. in length were was also noted. Although the depth could not be determined, a buildup of sediment on the upstream face of the wall was visible from the crest.

The headworks and adjacent wing wall were also generally in fair condition. Several hairline cracks were noted which spanned the crest slab of the headworks. It was also visible that an attempt had been made to repair some of them. The downstream face above the old grinder room appears to be a gunite surface. (See Photo 10). This section is suffering from extensive hairline surface cracking with several spalled areas 3-4" in depth. Two areas of wetness, indicating minor seepage plus extensive efflorescence were also noted. From within the old grinder room and powerhouse some seepage was noted as a wetness across the old lift lines and from areas of old embedded steel. The efflorescence was severe in this area as evidenced by the calcium buildups on the face. The entire downstream face of the wingwall appears to be an old gunite surface. Extensive hairline surface cracking and efflorescence was noted across the entirety of the face. Two wet areas, indicating minor seepage, were noted right of the gatehouse.

Downstream of the left abutment is a guide wall (Photo 3) which is in fair condition. There are a number of longitudinal cracks up to 1/2" wide and 35 feet in length along the entire wall. Several spalled areas up to 2-3" in depth were also noted.

c. Appurtenant Structures - The two sections of the emergency spillway and the principal spillway are in good condition. There is minor spalling at the construction joints and several minor longitudinal surface cracks 1/4" -1/2" wide and up to 25 to 30 feet long on the downstream faces of each of the structures.

Flow was observed at the downstream toe of the emergency spillway (See Photo 6) about 150 feet left of the corner pier. It was reported that the flow was from a 4-6" PVC pipe which was embedded in an old mud gate at the time of the '72 rehabilitation of the spillway. The training wall at the downstream toe is in an advanced state of deterioration with extensive cracking and spalling of the concrete. At the toe, the wall has been capped with a steel plate to protect it from damage due to ice falling over the crest.

On the emergency spillway, the flashboards and their supports are in good condition. Minor rusting of the steel brackets on the supports and minor leakage was noted.

The tainter gates are experiencing minor rusting and leakage at the base. Operation of the gates was not demonstrated, however reportedly they were operated in the recent past.

The floating walkway is generally in good to fair condition. There is some vegetation growing in the walkway and within a small section the left side of the walkway submerges under the weight of a person on the walkway.

The fishway and the 42" Ø penstock are each in good condition (See Photo 8). In addition, the control gates for each structure appeared to be in good condition. Neither was operated during the inspection.

The gates for the turbines were not visible. Their control mechanisms at the crest of the headworks were slightly rusted. They were not operated during the inspection, however they are reportedly operated daily.

The powerhouse was in good to fair condition. The interior was visibly maintained and in good condition. The downstream wall at the tailrace was showing some signs of distress. Several small areas of spalling 1-2" in depth with some efflorescence was noted. (See Photo 11).

d. Reservoir Area - The pool created by Woodland Dam is generally bordered by undeveloped, heavily forrested relatively flat

terrain. About 1,000 feet upstream of the site the small community of Woodland Junction borders the pool. A railroad bridge crosses the pool at this point. The pool is long and narrow, having a length of about 8,500 feet and an average width of about 1,000 feet. No conditions have been noted that would result in a sudden increase in sedimentation.

3.2 Evaluation

Based on the visual examination conducted on 11 August 1981, Woodland Dam is considered to be in fair condition. The cracking, spalling and seepage noted regarding the hydraulic wall, headworks and adjacent wingwall and guide wall below the left abutment are of concern and will require remedial action. Also, the flow at the downstream toe of the emergency spillway will require further investigation. Minor problems regarding the concrete on the downstream faces of the spillways and powerhouse will also require remedial action.

Two other points should be noted which could affect the safety of the structure. First, there is no low level outlet for the project. If an emergency situation arose, flow thru the powerhouse could lower the pool to El. 120. however 17' of water would still remain in the pool.

Second, utilization of the floating walkway to remove the flashboards during flood conditions could present a safety risk.

Recommendations and remedial measures as outlined in sections 7.2 and 7.3 should be implemented to correct the noted deficiencies.

SECTION 4

OPERATIONAL AND MAINTENANCE PROCEDURES

4.1 Operational Procedures

a. General - The emergency spillway is two levels and each is fitted with flashboards. The principal spillway is controlled by five tainter gates. Normal flows are passed through the powerhouse in accordance with the formal operation procedures. When flows exceed the capacity of the powerhouse the engineering staff is notified. Normally the tainter gates are then operated and if their capacity is exceeded then the flashboards are removed. The tainter gates are operated by hand but an air pressure tool is available on the site and is sometimes used. The flashboards are removed from the floating walkway.

b. Description of Downstream Warning System - No warning system or emergency evacuation plans are in effect for this project. However, an emergency plan is in effect (see Appendix B) for three of Georgia Pacific's dams upstream and this plan could be easily expanded to include Woodland.

4.2 Maintenance Procedures

a. General - No written formal maintenance procedures were indicated for the project. A maintenance crew is on the site daily, thus any emergency repairs can be initiated on a moment's notice. It was also noted that the Power and Utilities Area Engineer conducts annual technical inspections of the facilities.

b. Operating Facilities - There are extensive operating facilities at this project. They include all of the facilities within the powerhouse including the gates and the turbines plus the sluice gate on the process water intake, the tainter gates and the flashboards. No written formal maintenance procedures for these project operating facilities are specified however they are regularly maintained by personnel on hand.

4.3 Evaluation

The operating procedures for this project are extensive and appear quite adequate. The downstream warning system established by Georgia Pacific for their other structures is adequate and should be expanded to include Woodland.

The maintenance personnel at the site maintain the site on an informal basis at the direction of the engineering staff. It is recommended that formal maintenance procedures be established for

the project. The Owner should continue to have a technical inspection made of the project annually, under the direction of a registered professional engineer.

SECTION 5

EVALUATION OF HYDROLOGIC AND HYDRAULIC FEATURES

5.1 General

The drainage area for Woodland Dam is 1350 square miles. The entire area could be considered a wilderness area with a few rural communities scattered across a basin of rolling terrain. Georgia-Pacific Corp. owns, operates and maintains a series of control structures in the upper basin. To account for this storage in the upper basin, the hydrologic computations were based upon a basin considered as flat, coastal terrain. The dam is located on the St. Croix River in Baileyville, Maine, U.S.A. and St. Stephen, New Brunswick, Canada.

5.2 Design Data

The 1972 rehabilitation of the dam was designed by Neill and Gunter Limited. The top of the dam elevation is at El. 142.21 with a maximum height of 39 feet (capacity 4380 ac. ft.). The principal spillway consists of a concrete sharp crested weir with five tainter gates. The dam is also equipped with an emergency spillway located adjacent to the principal spillway. There are two sections to the emergency spillway. The first is 583 feet 3 inches wide with a crest elevation of 134.21. The second section is about 200 feet wide with a crest elevation of 136.0. In addition there are 14 gates for the turbines with a maximum capacity of 3,000 cfs.

5.3 Experience Data

The flow records go back to 1915. Maximum recorded flood occurred in May 1923 with peak discharge of 23,300 cfs. There has never been an overtopping event recorded.

5.4 Test Flood Analysis

Based upon "Preliminary Guidance for Estimating Maximum Probable Discharge", dated March 1978, the watershed classification (flat and coastal), and hydraulic computations, the test flood for this high hazard, intermediate size dam is the PMF which is estimated to be 46,200 cfs (35 csm). Because of the very large drainage area behind this run-of-the-river dam, surcharge storage at the dam would not significantly attenuate large flood flows and the peak test flood inflow would equal the peak test flood outflow. Because of the manner in which this project is operated with successive gates being opened as the pool level rises, the maximum pool elevation for any flood depends on the rate and timing of gate openings. Consequently, it is not possible within the scope of this report to calculate the maximum pool level during a test flood routing. However, since the total project discharge capacity at the maximum pool level allowed by normal operating procedures (elevation 141.25) is 130 percent of the peak test flood outflow,

that pool level is not likely to be exceeded. The total project discharge capacity at the top of the dam of 70,500 cfs is 150 percent of the peak test flood outflow and the dam would not be overtopped. The test flood outflow of 46,200 cfs corresponds to a water surface elevation of 140.0.

5.5 Dam Failure Analyses

The volume in the reservoir corresponding to the water surface elevation 142.21 (top of the dam) is 4380 acre-feet which is considered at the time of dam failure. The impact of failure was assessed using the "Rule of Thumb, Guidance for Estimating Downstream Dam Failure Hydrographs" prepared by the Corps of Engineers. The breach discharge was estimated with the water surface elevation at the top of the dam. The breach width was selected to be 35 percent of the length of the dam at mid-height. The downstream discharge is a sum of the breach discharge and the discharge from the principal and emergency spillways. The total peak discharge was estimated to be 244,000 cfs. This peak discharge increased the estimated prefailure water depths 50 ft. downstream from 19' to 35'. The calculations for this analyses are included in Appendix D.

In view of these results it can be concluded that a failure would seriously damage the Woodland Paper Plant immediately downstream with water depths ranging up to 16 feet. The plant is manned 24 hours a day, thus, this dam represents a high hazard structure since it can be assumed that more than a few lives would be lost in the event of a dam failure.

SECTION 6

EVALUATION OF STRUCTURAL STABILITY

6.1 Visual Observations

There was no visual evidence of structural instability in the spillways, hydraulic wall, headworks or left abutment. All appeared to be performing satisfactorily under static loading conditions.

The hydraulic wall headworks and wingwall adjacent to the headworks are all showing some signs of deterioration with surface cracking, seepage, efflorescence and spalling of the concrete. In addition, it was noted that a significant amount of sediment is deposited on the upstream face of the hydraulic wall. The guide wall downstream of the left abutment is experiencing extensive cracking and spalling. Although these structures appear structurally sound the conditions noted are significant and warrant investigation and/or repair.

6.2 Design and Construction Data

Two original design drawings dated 1905 were located. Design plans dated June 1972 for the rehabilitation of the Canadian spillway were also located. Three as built drawings relative to the 1972 rehabilitation of the emergency spillway were also reviewed.

6.3 Post Construction Changes

There have been several modifications to the Woodland Dam since its construction in 1905. The four larger generators were installed in the old grinder room. In 1965, new generators were installed to the grinder room. In 1943, as noted in the design drawings for the '72 rehabilitation, the spillway was gunited. It is believed that the entire dam might have received this treatment. In 1953, as noted in the Chas. T. Main report, the crest of the headworks was replaced to its present day configuration. In 1965, the logway was removed and the 42" Ø process water penstock was installed. In 1972, the Canadian section of the emergency spillway was rehabilitated, the crest raised and the floating walkway replaced. Although not noted in the drawings, the American section of the emergency spillway and the principal spillway were rehabilitated, the crest raised and the tainter gates added as part of the 1972 contract. In 1963 the fishway was replaced to its present day configuration.

6.4 Seismic Stability

The dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7

ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition - The visual examination of Woodland Dam revealed that the dam was in fair condition. Although there were no signs of impending structural failure or other conditions which would warrant urgent remedial action, deficiencies regarding the hydraulic wall, headworks and adjacent wingwall, and guide wall downstream from the left abutment were noted.

b. Adequacy of Information - The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data but is based primarily on visual inspection, past performance history and sound engineering judgement.

c. Urgency - The recommendations and remedial measures presented below should be implemented by the owner within one year of receipt of this Phase I Inspection Report, except as otherwise noted.

7.2 Recommendations

It is recommended that the owner engage the services of a registered professional engineer experienced in the design and construction of dams to perform the following:

a. Investigate the integrity of the hydraulic wall, headworks and adjacent wingwall and guide wall downstream of the left abutment. Based upon this investigation design and supervise implementation of the recommended repair schemes for each structure.

b. Prepare a set of complete drawings on the site noting all civil structural dimensions including NGVD elevations, and all mechanical and electrical aspects of the project.

c. Investigate the sedimentation at the upstream face of the structure and supervise implementation of the recommendations of the investigation.

d. The floating walkway is inadequate for current operating procedures for safety of personnel. It is recommended that a more permanent alternate means of access to remove the flashboards (i.e., a catwalk) be investigated. Based upon this investigation, design and supervise implementation of the recommended alternative.

e. Design and supervise construction of a low level outlet or an alternative means of dewatering the reservoir.

f. Investigate the flow from the 4-6" PVC pipe at the downstream toe of the spillway and design and supervise implementation of any recommended repairs. Until the investigation is initiated monitor the flow daily. If the amount or color of the flow changes initiate the investigation immediately.

7.3 Remedial Measures

The owner should:

a. Expand their existing emergency evacuation plans for their upstream dams to include Woodland dam.

b. Repair the minor cracking and spalling on the downstream face of the spillways and the powerhouse.

c. Prepare an operations and maintenance manual for the dam. The manual should include the normal operation procedures as noted in Appendix B and routine maintenance work to be done on the dam to minimize deterioration of the facility and ensure safe, satisfactory operability.

d. Under the direction of a registered professional engineer conduct annual technical inspections of the dam including all civil-structural, geotechnical, mechanical and electrical aspects of the project.

e. Compile and maintain a file of plans available regarding repairs to the structure by task in chronological order.

7.4 Alternatives

There are no practical alternatives to the recommendations as outlined in Sections 7.2 and 7.3.

APPENDIX A - INSPECTION CHECKLIST

INSPECTION CHECK LIST

PARTY ORGANIZATION

PROJECT Woodland Dam

DATE 11 August 1981

TIME 8:00

WEATHER Cloudy

W.S. ELEV. ____ U.S. ____ DN.S

PARTY:

1. J.E. Giles Jr., Project Manager
2. Gary D. James, Civil Engineer
3. Turan Otova, Hydrologist
4. Kenneth Gordon, Mechanical Engineer Georgia Pacific
5. Mason Pottle, Georgia Pacific
6. ____
7. ____
8. ____
9. ____
10. ____

	PROJECT FEATURE	INSPECTED BY	REMARKS
1.	All project features were inspected by each of the party members.		
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

INSPECTION CHECK LIST

PROJECT Woodland Dam

AREA EVALUATED	CONDITIONS
DAM	
Crest Elevation	El. 141.0
Current Pool Elevation	El. 140.0
Max. Flow to date	23,000 cfs May 1923
Type	Concrete gravity structure includes Headworks to powerhouse and gate-house for 42" Ø process water intake.
Upstream Face	Not visible
Downstream Face Above Powerhouse Roof	Badly spalled with areas visible where attempt was made to correct problem. One minor area of moisture from seepage.
Adjacent to Spillway at Process Water Intake	Concrete badly spalled with a longitudinal crack at the top of the section. 6-10 areas of seepage visible.
Crest at Headworks Area	Some cracks visible, some have been repaired.
Downstream Face in:	
Powerhouse (far right)	Seepage visible at nearly all old lift lines and at areas of old unbedded steel. Efflorescence and staining visible across entirety of structure.
Units #4, 5 & 6	Minor seepage and efflorescence.
Crest Beyond Powerhouse	New slab has been placed on crest in this area.
Downstream Face Beyond Powerhouse	Seepage is visible at all of the old lift lines. Old plant is being torn down, difficult to distinguish between old wall of plant and dam.
NOTE:	Appears to be a great deal of sediment on U/S face of this section of dam.

INSPECTION CHECK LIST

PROJECT Woodland Dam

AREA EVALUATED	CONDITIONS
HEAD WORKS	
a. Approach Channel	
Slope Conditions	N/A
Bottom Conditions	Not visible
Log Boom	3 log booms 1 - 50 yards in front of headworks 1 - 150 yards in front of entire dam 1 - 300 yards in front of entire dam
Debris	Minor floating
Drains or Weep Holes	Not visible
b. Mechanical and Electrical	

INSPECTION CHECK LIST

PROJECT Woodland Dam

AREA EVALUATED	CONDITIONS
HEAD WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL	
General Condition of Concrete	on D/S face - fair condition
Rust or Staining	None visible
Spalling	Extensive
Erosion or Cavitation	
Visible Reinforcing	None visible
Any Seepage or Efflorescence	Some at all lift joints
Condition at Joints	Efflorescence and spalling at all left lines
Drain Holes	None visible
Channel	
Loose Rock or Trees Overhanging Channel	Minor brush
Condition of Discharge Channel	Good - masonry lined channel

INSPECTION CHECK LIST

PROJECT Woodland Dam

AREA EVALUATED	CONDITIONS
SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None visible
Trees Overhanging Channel	None
Floor of Approach Channel	Not visible
b. Weir and Training Walls	
General Condition of Concrete	Good to excellent - minor cracking and staining on D/S face
Rust or Staining	
Spalling	None visible
Any Visible Reinforcing	None
Any Seepage or Efflorescence	Minor
Drain Holes	Across entire D/S face
c. Discharge Channel	
General Condition	Exposed bedrock
Loose Rock Overhanging Channel	None
Trees Overhanging Channel	Treed Island splits channel.
Floor of Channel	Loose rock with exposed bedrock
Other Obstructions	Training wall keeps spillway outflow in right channel.
	Spillway is equipped with 5 tainter gates 6' high x 12' wide.
	Excellent condition, Minor leakage around edges
	Normally by hand, however, compressed air jack can and is sometimes used.

INSPECTION CHECK LIST

PROJECT Woodland Dam

AREA EVALUATED	CONDITIONS
EMERGENCY SPILLWAY	
Crest Elevation	2 levels with 7' of flashboards on section across river and 5' of flashboards on sect. adj. to spillway.
Current Pool Elevation	
Maximum Impoundment to Date	
Surface Cracks	Minor on D/S face
Pavement Condition	N/A
Movement or Settlement of Crest	None Visible
Lateral Movement	None Visible
Vertical Alignment	Excellent
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Left abutment badly spalled with long cracking
Indications of Movement of Structural Items on Slopes	None
Trespassing on Slopes Vegetation on Slopes Sloughing or Erosion of Slopes or Abutments	N/A
Rock Slope Protection - Riprap Failures	N/A
Unusual Movement or Cracking at or near Toes	N/A
Unusual Embankment or Downstream Seepage	Minor leakage around flashboards.
Piping or Boils Foundation Drainage Features Toe Drains	At corner water seen flowing at toe of dam explained as 4" pvc pipe in old mud gate.
Instrumentation System	N/A
Discharge Channel	
Floor of Channel	Loose Rock with bedrock outcropping
General	Training wall splits channel to go either side of Treed Island. Training wall is in poor condition but serves no useful purpose. Has steel plate on top at toe of spillway to protect against ice damage.

APPENDIX B - ENGINEERING DATA

6k) WOODLAND DAM & POWER STATION - DETAILS OF STORAGE AND CONTROL REGULATIONS:

I DAM:

Description:

Drainage Area - 1,350 Square Miles
High Water Surface Area - 800 Acres
High Water Elevation - 141' 4"
Maximum Allowable Elevation - 141' 4"
Normal Operating Elevation - 140' 4"
Effective Regulation - 2' 0"
Effective Capacity - 1,600 Acre Feet
Number of Gates - 18 (Boards)
Width of Gate Opengins - 120 Boards in Water
Fishway - East Side

Control Regulations:

1. Maintain a minimum flow in St. Croix River of 750 c.f.s.
2. Tending boards, trash racks, etc., is the responsibility of Grinder Room.
3. The Grinder Room will be notified by Grand Falls when a gate is opened or closed.

II POWER STATION:

Description:

1. Three - 1100 HP (750 KW) Hercules, Twin Horizontal Francis Turbines, 46 ft. Head.
2. Four - 1700 HP (1200 KW) S. Morgan Smith, Twin Horizontal Francis Turbines, 46 ft. Head - 440 c.f.s.

WOODLAND DAM & POWER STATION - DETAILS OF STORAGE & CONTROL REGULATIONS (Cont'd):

II POWER STATION (Cont'd):

Control Regulations:

1. Instructions as to Power Output of the seven generators will be issued from Engineering or the Steam & Power Control Room.

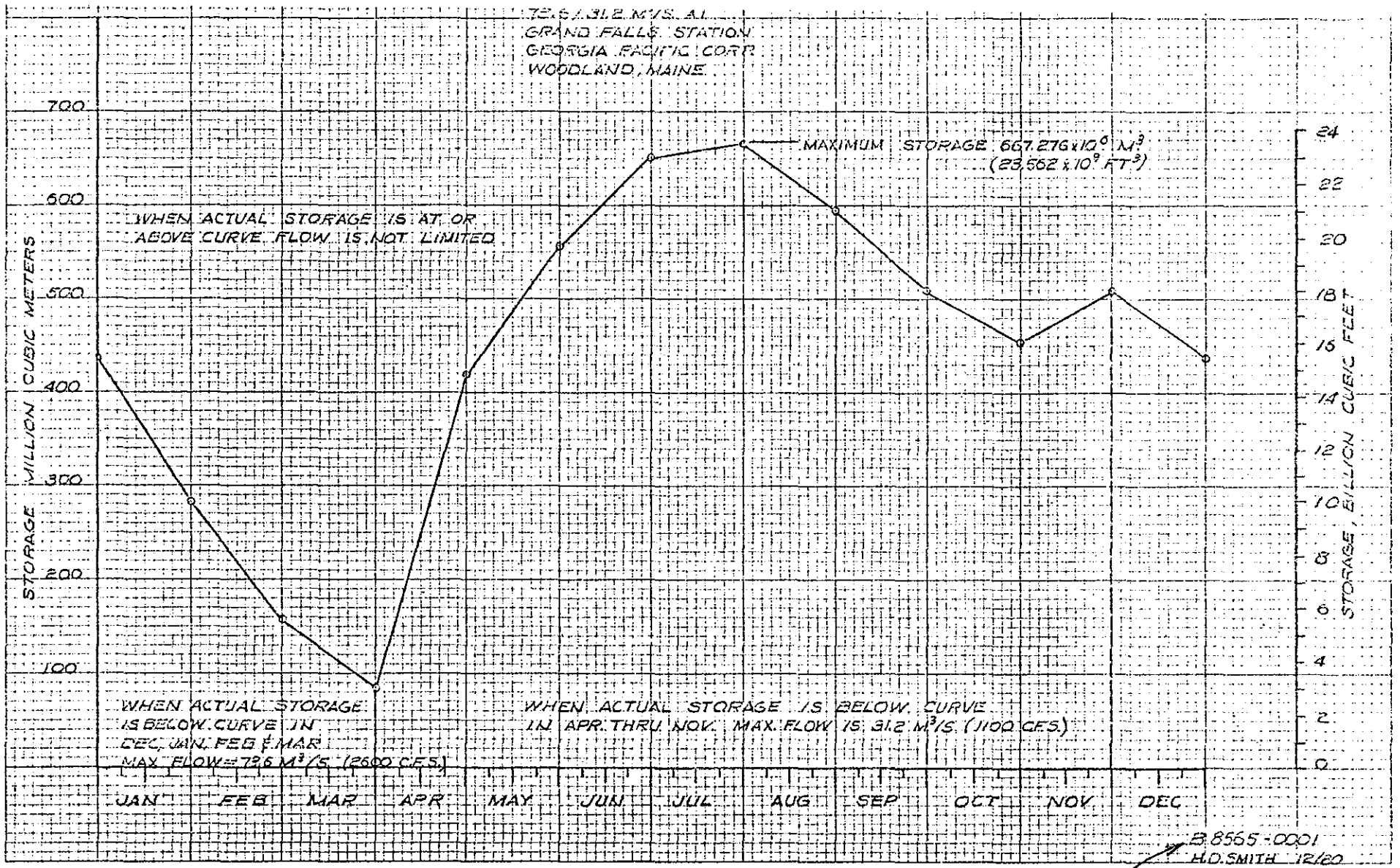
2. All changes in generation will be made by the shift electrician.

3. It is the responsibility of the Electrical Maintenance Department to insure that the shift electrician is in the Generator Room at 8:00 A.M. every morning. The shift electrician will fill out the Daily Log Sheet and report any unusual findings to the Engineering Department and the Steam & Power Control Room.

Inputs:

1. A change at Grand Falls is felt in 3 hours.

2. If the Pond drops or rises 1" in 24 hours a change of 75 c.f.s. in flow is required.



B.8565-0001
H.D.SMITH 12/80

G. R. Dug

47 0702

B - 3

Georgia-Pacific

company memo

J. JACKSON
R. RAMSDELL
D. Smith
G. Cox
J. REDDING
S.O.P MANUAL
3-9-81
J.

Distribution location

Ralph Feck location

Emergency Plans In The Event Of Dam Failure: date March 3, 1981

Attached please find an appropriate number of copies of Standard Operating Procedure No. 4. Responsible personnel are required to maintain a copy of this procedure at their designated work stations.

RECEIVED
MAR 9 1981
GEORGIA-PACIFIC CORPORATION
ENGINEERING DEPT.

Ralph Feck

RWF:bmt

Attachment

Dist: Federal Energy Regulatory Commission, Regional Engineer (3)
D. Johnston
B. Sparks
P. Jellison
R. Feck
V. Kavanaugh
A. Nichols
M. Lambert
S. Frost
J. Gallant (Wallace Security)
M. Cropley (c/o R. Scoville, St. Croix Office)
H. Bagley (c/o Princeton Office)
J. Wood (c/o Princeton Office)
C. Gilmore (c/o Princeton Office)
R. Scoville (St. Croix Office)
P. Neddeau (St. Croix Office)
Grand Falls Operator
S & P Foreman (4)
S & P Control Room
Generator Room
File

GEORGIA - PACIFIC CORPORATION

WOODLAND DIVISION

STANDARD OPERATING PROCEDURE

OPERATION:	PULP & PAPER	DATE ORIGINATED:	4-19-78
DEPARTMENT:	STEAM & POWER	DATE REVISED:	3-3-81
PROCEDURE NO:	4	PAGE 1 OF 6	

SUBJECT: EMERGENCY PLANS IN THE EVENT OF DAM FAILURE:

REFERENCES	OPR:	DEPT:	PROC. NO:

PURPOSE: The purpose of this procedure is to establish guidelines, or a plan of action, designed to minimize the hazard and effects of flooding upon downstream residents and industry in the event of failure of Forest City, Vanceboro or West Grand Lake Dam projects.

RESPONSIBILITY: See attached Figure 1, Communications Flow Chart Emergency Plan of Action in the Event of Dam Failure and Figure 2, Directory Listing.

IMPLEMENTATION:

A. Introduction

This procedure is issued in compliance with a directive issued August 25, 1975, by the Chief, Bureau of Power, Federal Power Commission and with subsequent instructions received from the F.P.C. These communications directed the operators of any licensed dam project to evaluate the potential for hazard to downstream residents and industry, largely on the basis of impounded water, location of downstream inhabitants and the flood capacity of downstream flowage.

Georgia-Pacific Corporation, Northeast Division, operates three (3) such licensed projects. In the evaluation of these projects, it was determied that the probability of failure was extremelv remote. However, if any of the three projects were to fail catastrophically, downstream residents and industry would likely be effected.

B. Definitions

1. Slowly Developing Failure

Any circumstances which indicate structural weakness or the potential for eventual failure. In general, any indication of development to a "rapidly developing failure" in the period of one week or more constitutes a failure of this nature.

IMPLEMENTATION: (cont'd)

Examples of these conditions are slowly developing cracks in concrete structure; binding of gates of movable components, indicating a structural shift; or leakage through, under or around the structure, dike or embankment.

2. Rapidly Developing Failure

A circumstance where a significant flow of water is, or will be, uncontrollable by-passing the structure; noticeable movement of the structure of the dike has occurred; or any situation which indicates that dam will not maintain the impounded volume for at least thirty (30) days.

3. Instantaneous Failure

That situation where significant uncontrollable flow is passing through, around or over the structure due to a breech, overturn, wash, etc.

C. General Instructions - Slowly Developing Failure

In a slowly developing failure, downstream inhabitants are not considered to be in immediate danger of flooding. However, immediate notification of supervisory and management personnel should be made so that investigation and corrective action may take place.

Responsibilities

1. Dam Tender, Employee of Reporting Individual

It is the responsibility of the Dam Tender to observe the structure and associated areas of his licensed project on a daily basis to assure the safe and stable condition of the dam.

OPERATION:	PULP & PAPER	DATE ORIGINATED:	4-19-78
DEPARTMENT:	STEAM & POWER	DATE REVISED:	3-3-81
PROCEDURE NO:	4	PAGE 3 OF 6	

SUBJECT: EMERGENCY PLANS IN THE EVENT OF DAM FAILURE:

REFERENCES OPR: DEPT: PROC. NO:

IMPLEMENTATION: (cont'd)

Any indication of a slowly developing failure shall be reported to the Hydro System Superintendent within not greater than eight (8) hours. (See the attached "Directory Listing, Figure 2, for personnel assigned these responsibilities, their alternates, with telephone numbers.

2. Hydro System Superintendent

Upon notification of a slowly developing failure in progress, the Hydro System Superintendent, or a qualified Engineer, shall visit the facility as soon as possible but not later than one (1) working day following notification. He shall conduct a thorough investigation, advise the Manager of Steam & Power of his findings, and implement further action to prevent further deterioration of the failure situation.

D. General Instructions - Rapidly Developing Failure

Under these circumstances, severe flooding has not yet occurred, however, the potential danger does exist. Therefore, every effort should be made to reduce the hazard and advise downstream inhabitants. The procedure for action and notification is outlined in Figure 1, Communications Flow Chart. This communications outline, in conjunction with the "Directory Listing" in Figure 2., provides a quick reference for action by responsible personnel.

Responsibilities

1. Dam Tender, Other Employee, or Reporting Individua

Upon observing the presence or indications of a rapidly developing failure, the Tender or Others shall:

OPERATION: PULP & PAPER DATE ORIGINATED: 4-19-78

DEPARTMENT: STEAM & POWER DATE REVISED: 3-3-81

PROCEDURE NO: 4 PAGE 4 OF 6

SUBJECT: EMERGENCY PLANS IN THE EVENT OF DAM FAILURE:

REFERENCES OPR: DEPT: PROC. NO:

IMPLEMENTATION: (cont'd)

a) Notify the Grand Falls Operator that "A Rapidly Developing Failure" is in progress at ( ) dam.

b) Open all available gates or spillways to reduce the pressure on the failing structure.

c) Attempt to reduce further development of failure by whatever means possible.

d) Notify, by best means, local area residents.

2. Grand Falls Operator

Obtain accurate and reliable information from the Tender or Reporting Individual. Then notify the people listed in Figures 1 & 2, attached, as follows:

a) Hydro System Superintendent - The Hydro Superintendent may request additional information or may at this time intervene and direct the notification and action by an alternate method.

b) Notify the Steam & Power Operator.

c) Direct the Lead Maintenance Man and his Helper to report.

d) Load all available hydro generation to capacit

e) Notify Tenders of other dams to "close in" to minimum flow (except in the case of a failure at Forest City, then, direct the Vanceboro Tender to open one (1) gate full open).

f) Woodland Mill Security - Be sure to specify that a "Rapidly Developing Failure" is in progress, however, downstream flooding has not yet occurred.

OPERATION:	PULP & PAPER	DATE ORIGINATED:	4-19-78
DEPARTMENT:	STEAM & POWER	DATE REVISED:	3-3-81
PROCEDURE NO:	4	PAGE 5 OF 6	

SUBJECT: EMERGENCY PLANS IN THE EVENT OF DAM FAILURE:

REFERENCES OPR: DEPT: PROC. NO:

IMPLEMENTATION: (cont'd)

3. Woodland Mill Security

Obtain accurate information; if necessary contact the Tender or Reporting Individual directly. Once the type and extent of failure is accurately known, notify all persons and organizations in the attached "Directory Listing, Fig. 2", under "Outside Notification" that a failure is developing at the ( ) dam and that downstream inhabitants should be alerted to the possibility of flooding in the St. Croix River and/or tributaries.

4. Steam and Power Operator

Direct the Generator Room Operator to start and load all available hydro units at the Woodland station. Direct the Steam Plant Foreman to report to the dam with a crew of four (4) to six (6) people and open all five (5) waste gates.

5. Hydro System Superintendent

The primary responsibilities of this person are t

a) Establish a control center at the Steam and Power Control Room or the Generator Room.

b) Obtain all available information and direct all further operations.

c) Notify the Manager of Steam & Power and the F.P.C. Regional Engineer.

D. General Instructions - Instantaneous Failure

In this instance, it is assumed that the project has experienced a catastrophic failure and a resulting flood crest is rapidly advancing downstream. Under these circumstances, all concerned personnel perform

STANDARD OPERATING PROCEDURE

OPERATION:	PULP & PAPER	DATE ORIGINATED:	4-19-78
DEPARTMENT:	STEAM & POWER	DATE REVISED:	3-3-81
PROCEDURE NO:	4	PAGE 6 OF 6	

SUBJECT: EMERGENCY PLANS IN THE EVENT OF DAM FAILURE:

REFERENCES OPR: DEPT: PROC. NO:

IMPLEMENTATION: (cont'd)

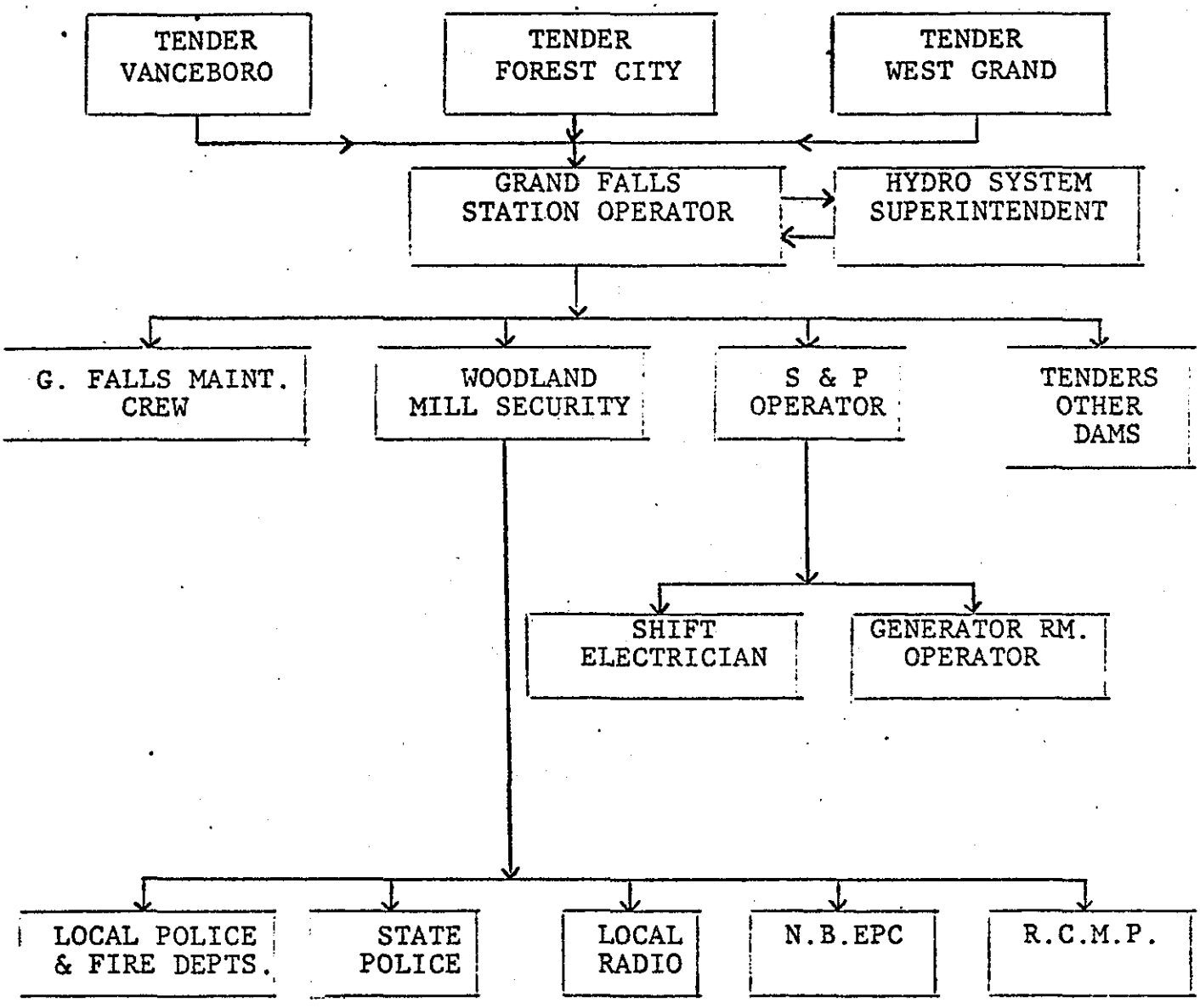
their functions as they are outlined under "Rapidly Developing Failure", with the following exceptions:

a) The failure shall be described as "instantaneous" rather than "rapidly developing" and,

b) The Mill Securtiy will contact the persons and organizations on his list and state that an "emergency" exists and downstream residents and industry will be subjected to flooding of various degrees and that evacuation of lowland river areas commence immediately.

FIGURE 1

COMMUNICATIONS FLOW CHART



DIRECTORY LISTING - FIGURE 2

		TELEPHONE NUMBERS		
		WORK	HOME	MILL EXT.
FOREST CITY DAM TENDER:	MORRIS CROPLEY	448-2445	506-894-2435	
" " " ALTERNATE:	ROBERT SCOVILLE		506-784-2793	1779
WEST GRAND LAKE TENDER:	HAZEN BAGLEY		207-796-2689	
" " " ALTERNATE:	CHARLES GILMORE		207-796-2909	1777/1778
VANCEBORO DAM TENDER:	ROBERT SCOVILLE		506-784-2793	
" " " ALTERNATE:	PEGGY NADEAU		506-784-2817	
GRAND FALLS OPERATOR (24 Hrs.)		427-3276		1433
MILL SECURITY (24 Hrs.)		427-3311		1368
STEAM & POWER (24 Hrs.)		427-3311		1430
SHIFT ELECTRICIAN (24 Hrs.) MILL TELEPHONE PAGE 64-212				
HYDRO SYSTEM SUPERINTENDENT:	RALPH FECK	427-3311	454-3394	1424
" " " ALTERNATE:	DENNY JOHNSTON		454-7376	1114
" " " "	PAUL JELLISON		454-7863	1422
MANAGER OF STEAM & POWER:	BEN SPARKS		454-7471	1421
F.P.C. REGIONAL ENGINEER:			212-264-3687	

OUTSIDE NOTIFICATION (BY MILL SECURITY)

1. REGIONAL CIVIL DEFENSE
2. VANCEBORO: POLICE - DIAL "O" - FIRE - DIAL "O"
3. PRINCETON: POLICE - DIAL "O" - FIRE - 796-2288
4. WOODLAND: (MILL SECURITY IS POLICE & FIRE DISPATCHER)
5. CALAIS: POLICE - 454-2161 - FIRE - 454-2212)
6. MILLTOWN: " " " "
7. ST. STEPHEN, N.B.: DIAL "O" FOR POLICE & FIRE
8. MAINE STATE POLICE: 866-2122
9. WQDY RADIO STATION: 454-7545
10. R.C.M.P.: 506-466-2477
11. EASTERN MAINE ELECTRIC CO-OP: 454-7555

. M. SUSSEY
. F. UHL
. M. HALL
. W. LOGAN
. JACOBS
. R. RICH
. T. COLBURN

CHAS. T. MAIN, INC.
80 FEDERAL STREET
BOSTON 10, MASS.

December 2, 1958

543-36

SUBJECT: Condition and Safety of Woodland and Grand Falls Dams

Mr. Henry W. Fales, Vice President
St. Croix Paper Company
Woodland, Maine

Dear Mr. Fales:

Pursuant to your order of July 28, 1958, our Engineers, Lee Wolman and Fred Davis, inspected subject dams on September 23 and 24, 1958; and we have prepared the attached illustrated report on their condition and safety.

Very truly yours,

CHAS. T. MAIN, INC.

By

R. T. Colburn

LMW/n
Enc. 3 Reports (1 illustrated)

cc: M. Jacobs

REPORT

on

CONDITION AND SAFETY

of

WOODLAND AND GRAND FALLS DAMS

ST. CROIX PAPER COMPANY
WOODLAND, MAINE

CHAS. T. MAIN, INC.

Boston, Massachusetts

Charlotte, North Carolina

543-36-1

December 2, 1958

REPORT
on
CONDITION AND SAFETY
of
WOODLAND AND GRAND FALLS DAMS

ST. CROIX PAPER COMPANY
WOODLAND, MAINE

INDEX

SUMMARY

This report is based on a thorough inspection of the Woodland and Grand Falls Dams made in September 1958. It brings up to date the Report on Inspection and Condition of Woodland and Grand Falls Dams, Chas. T. Main, Inc., 543-9-1, December 1953. The 1953 report included a general description and history, and a description of the condition of each dam, to which any one reviewing this report may wish to refer.

In the 1953 report the condition of the dams was described in part as follows: "Both dams are now in fair condition. They are essentially of sound, permanent, concrete construction and adequate design and have stood the test of time. Most of their exposed concrete surfaces have weathered considerably and consequently have a poor appearance. This deterioration is of little consequence structurally at present, but it will tend to accelerate and will eventually have to be repaired". This description is still applicable, but the dams are now five years older, the eventual need for major repairs is therefore closer and some minor repair work at Grand Falls Dam would now be advisable.

Woodland Dam is a mass concrete gravity dam while Grand Falls Dam is a reinforced concrete slab and buttress, or hollow gravity, dam. Both dams were built more than 40 years ago. Our inspection indicated that, as would be expected, deterioration has progressed further at Grand Falls than at Woodland during the last five years. Most of the deterioration at Grand Falls has occurred in the Gunite facing applied some 15 years ago to protect exposed surfaces that were deteriorating then. At both locations, however, the dams are still unquestionably safe.

In the report, a small section of Grand Falls Dam has been singled out for repair, and a suggested method of repair described. It is recommended that this repair be made during the coming construction season. Thereafter, regular inspection by the company maintenance department, particularly after any unusually high spillway floods or ice flows, and subsequent prompt performance of repairs where necessary, should continue to insure the safety of the dams. The time may come, sooner or later, when the cost of necessary regular maintenance becomes excessive. A major resurfacing project should then be considered. If there is no earlier need, we recommend that another complete inspection, similar to this and the one in 1953, be made in 1963.

WOODLAND DAM

Present Condition

1. Downstream Face of Main Dam. - The downstream face of the dam presented much the same appearance as described in 1953. See photographs 1-11. No evidence of leakage through the dam was found. Leakage through the flashboards was responsible for the wet downstream face of the dam. Along the approximately horizontal strata between successive original concrete pours, it was possible to insert a rule about 9 inches on the average. this is equivalent to about 7 inches normal to the face of the dam. There were deeper depressions and cracks, principally at the original construction joints; the deepest opening observed was about halfway up the face of the dam in the stepped construction crack above the north edge of the northern most sluiceway and measured 17 inches back of the face of the dam. See photograph 3. Under the sixth flashboard bracket north of the division wall, about halfway down the face of the dam the rule was inserted 20 inches horizontally. See photograph 6. Just under the first concrete bracket pier north of the division wall there was a depression about one square foot in area and 11 inches deep (normal to the dam face). See photograph 7. About 8 feet below the bottom of the ninth bracket pier south of the division wall there was a depression 15 inches deep (normal). See photograph 5. No erosion was evident under the toe of the dam.

2. Spillway Training Wall at Canadian Abutment. - There was an irregular crack about 3 feet above the stilling pool water level in the side of this wall facing the dam; and an enlargement of this crack measured approximately 12 inches high by 18 inches long by 10 inches deep.

3. Sluiceways. - A horizontal crack and bulge was observed and measured in the north face of the wall of the second sluiceway from the north. See photograph 3. The general appearance of this bulge and the fact that there was no bulge in evidence on the south face of the same wall suggested that it is as old as the dam itself and resulted from a form slippage during construction. Nevertheless, the following measurements were made, and it is suggested that they be checked at one year intervals for two or three years to determine whether there is or is not any movement there:

> At a cross-section of the second sluiceway from the north, 18 feet east of the face of the sluice gate: top width - 5 feet-8 inches; width 56 inches up from bottom - 5 feet-7 inches; bottom width - 6 feet-0 inches.

The only leakage observed occurred at the two northern-most gates, where approximately 20 gpm was flowing at the south top corner and 5 gpm at the north top corner of the northern-most gate, and 60 gpm was spouting from the north top corner of the adjacent gate.

4. Division Wall. - The condition of this wall has not changed appreciably in the last five years.

5. Wing Dam. - The condition of the Wing Dam has not changed appreciably in the last five years. See photographs 12-14.

6. Flashboards. - No inspection of the flashboard brackets was made. It is understood that the brackets are inspected annually and repairs are made as necessary. Deterioration of the concrete pedestals that support the overhanging ends of the brackets on the Main Dam has progressed but slightly in the last five years. Gunite below the flashboards on the spillway lip of the Wing Dam has not deterioriated appreciably in that period.

7. Hydraulic Wall. - There has been no change of any consequence in the condition of the Hydraulic Wall in the Mill since 1953. No spouting leaks were observed. A flow of approximately 4 gpm was emerging from back of the Gunite facing on the wall in the grinder room, opposite the first water wheel and about 4 inches above the floor.

The reinforced concrete deck over the intake well has been replaced. Work is in progress on refacing the part of the downstream face of the wall back of this deck, above the grinder room roof.

8. Bubbler System. - The compressed-air bubbler system is reported in good operating condition.

Recommendations

1. General. - A regular inspection of all features of the dam should be made by the company maintenance department each year after the spring floods, and the results reported on. The report should be comprehensive and include photographs, leakage rates, reference measurements wherever any progressive movement or deterioration is suspected, and recommended maintenance work. A description of all maintenance work performed and a record of annual expenditures on maintenance should be filed with the annual reports. A file thus compiled will be of considerable value when future maintenance policy is formulated.

2. Flashboards. - Flashboards should be made as tight as possible before the freezing season.

PLEASANT L.

SCRAGGLY

JUNIOR L.

OBSIS DAM
PACITY - 24,900 AFT (MAX.)
INAGE AREA - 62.50 MI.
X. EL. - 305.62 MSL

POCUMSUS L.

WEST GRAND L.

CAPACITY - 160,900 AFT (MAX.)
DRAINAGE AREA - 224 SQ. MI.
MAX. EL. - 301.43 MSL

WEST GRAND L. DAM

SYSLADOBSIS L.

WABASSES L.

DYKE

THIRD MACHIAS L.

E. MUSQUASH L.

W. MUSQUASH L.

LONG L. - LEWYS L. - BIG LAKE

CLIFFORD DAM

CAPACITY - 16,700 AFT (MAX.)
DRAINAGE AREA - 14 SQ. MI.
MAX. EL. - 220.76 MSL

CLIFFORD L.

EAST GRAND L.

FOREST CITY DAM

CAPACITY - 105,300 AFT (MAX.)
DRAINAGE AREA - 138 SQ. MI.
MAX. EL. 434.94 MSL

SPEDNIK L.

VANCEBORO DAM

CAPACITY - 187,100 AFT (MAX.)
DRAINAGE AREA - 417 SQ. MI.
MAX. EL. - 385.86 MSL

LAMBERT L.

TOMAH L.

CAPACITY - 14,870 AFT (MAX)
DRAINAGE AREA - 51 SQ. MI.
MAX. EL. - 317.59 MSL

CANOOSE L.

CANOOSE DAM

GRAND FALLS FLOWAGE

CAPACITY - 88,000 AFT (MAX.)
DRAINAGE AREA - 1320 SQ. MI.
MAX. EL. - 198.6 MSL

WOODLAND

CAPACITY -
DRAINAGE AREA - 1350 SQ. MI.
MAX. EL. - 140.6 MSL

MILLTOWN

OCEAN

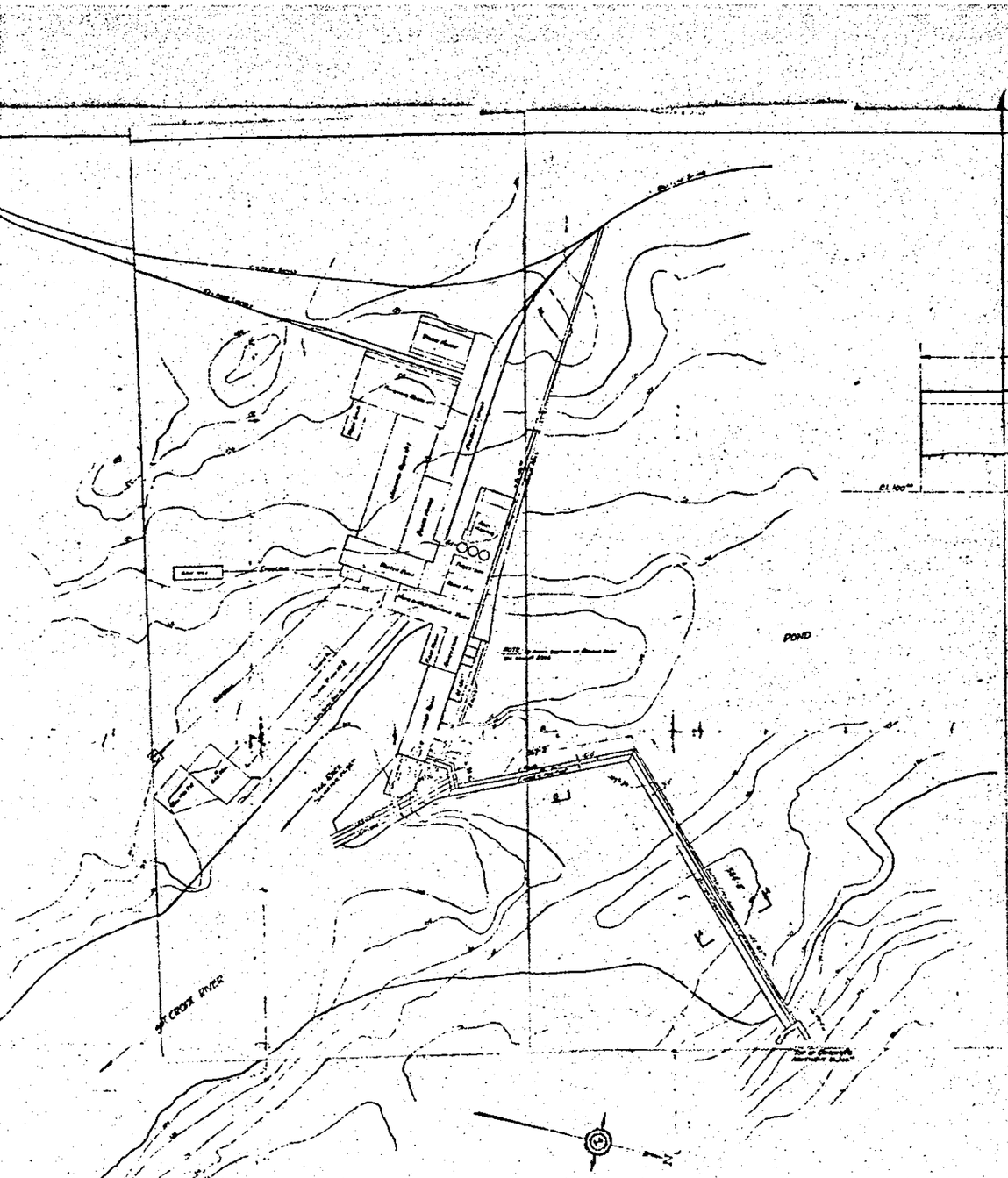
- - - INDICATES LAKES WITH DAMS REMOVED

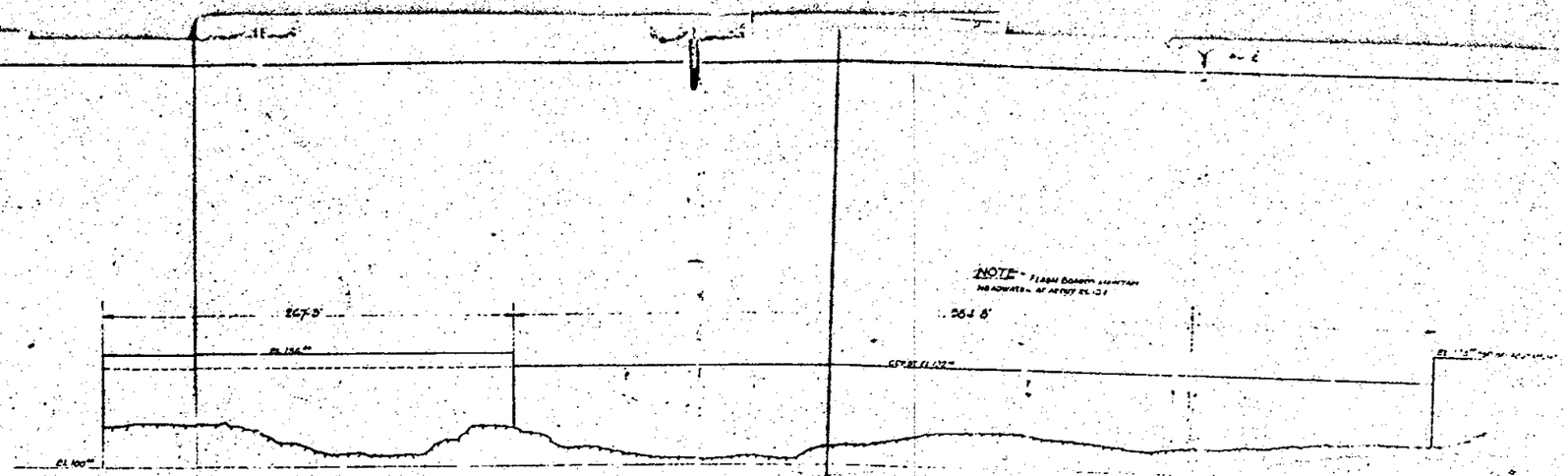
NO	DATE	REVISION	DR'N	CH'K'D

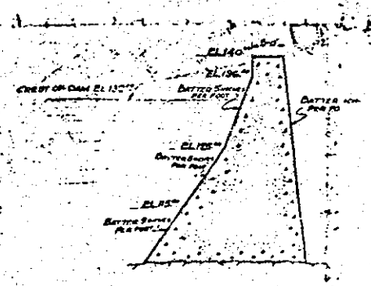
GEORGIA-PACIFIC CORPORATION
WOODLAND, MAINE

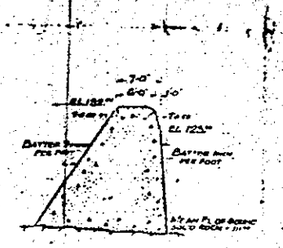
ONE LINE DIAGRAM
ST CROIX WATERSHED

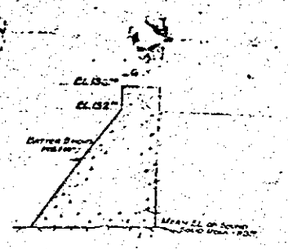
JOB NO		EQUIP. NO			
SCALE	NONE	NO	DAY	YR	DRAWING NO
DRAWN	B.D.S.	1		74	
CHECKED	G. COX	1		74	B18 - 6001
APPROVED		1	2	74	











SCALE 1"=10'-0"

GENERAL ... OF MILL SITE

PLAN & SECTIONS OF DAM

ST. CROIX PAPER CO.

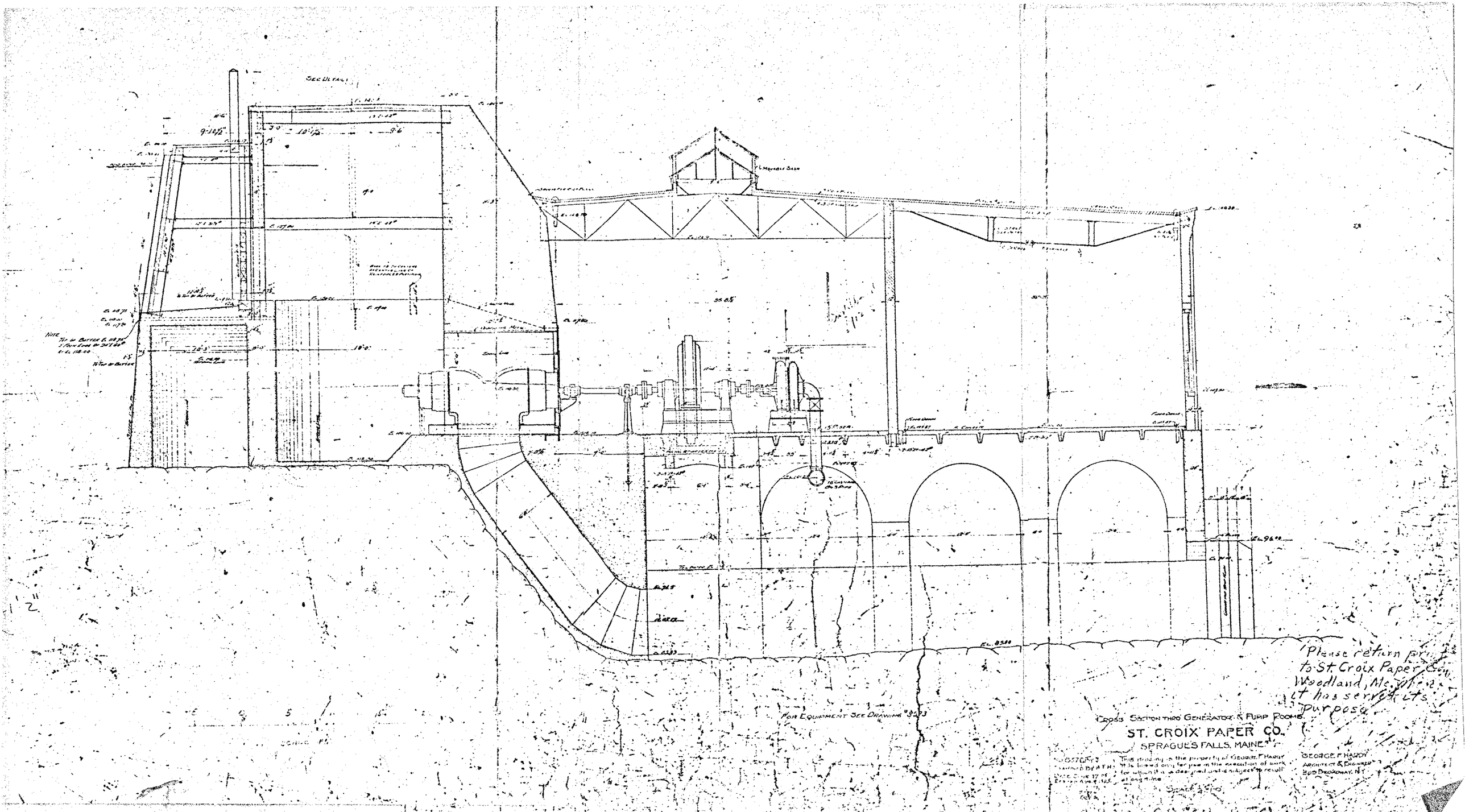
WOODLAND - MAINE

not to scale

G-104

GPNO. 83564-0506

No 11950

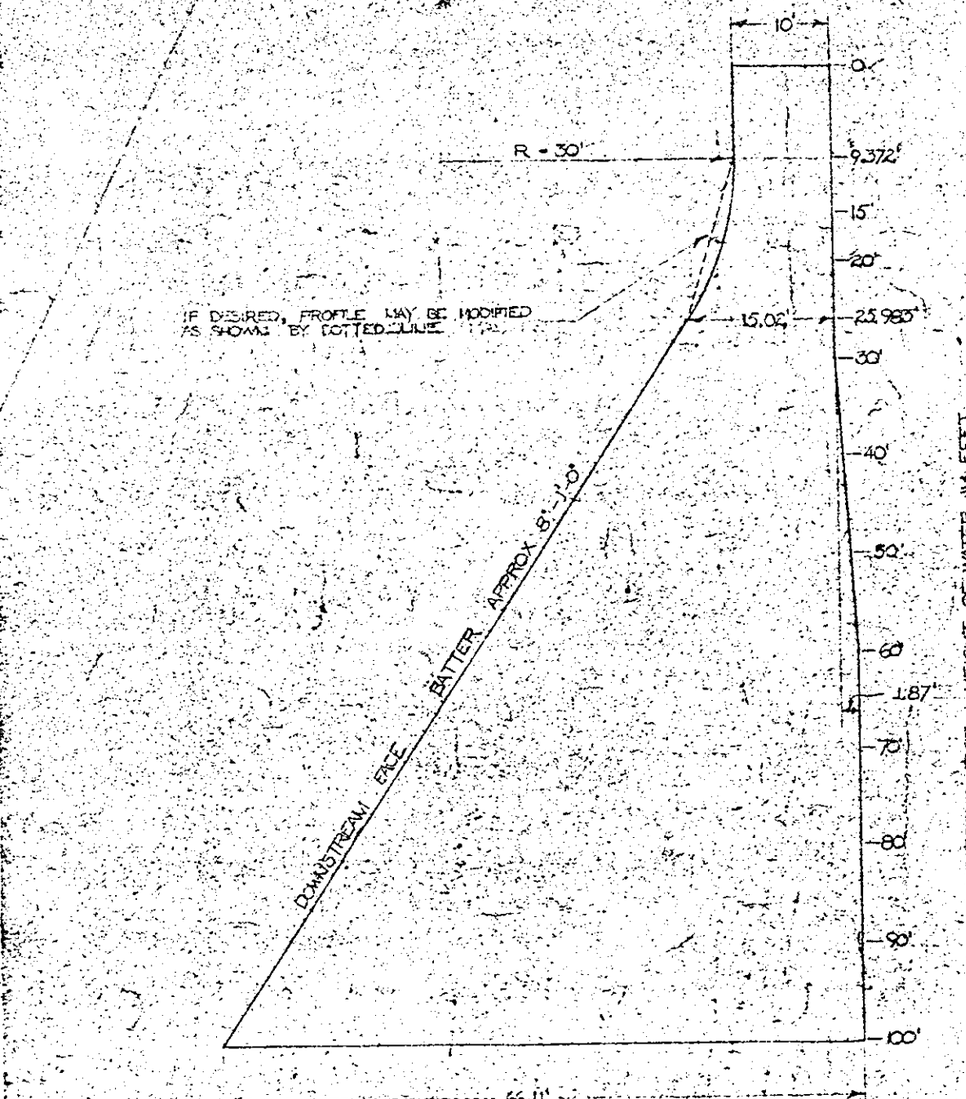


CROSS SECTION THRO GENERATOR & PUMP ROOMS.

ST. CROIX PAPER CO.

SPRAGUES FALLS, MAINE.

GEORGE F HARDY
ARCHITECT & ENGINEER
309 BROADWAY, N.Y.



EXPLANATION OF PROFILE

100' HEIGHT WAS CHOSEN FOR CONVENIENCE. DIMENSIONS FOR ANY OTHER HEIGHT MAY BE OBTAINED BY DIRECT RATIO. A DAM OF 40' HEIGHT WOULD REQUIRE A TOP WIDTH OF 4' AND ALL OTHER DIMENSIONS WOULD BE SCALED IN PROPORTION.

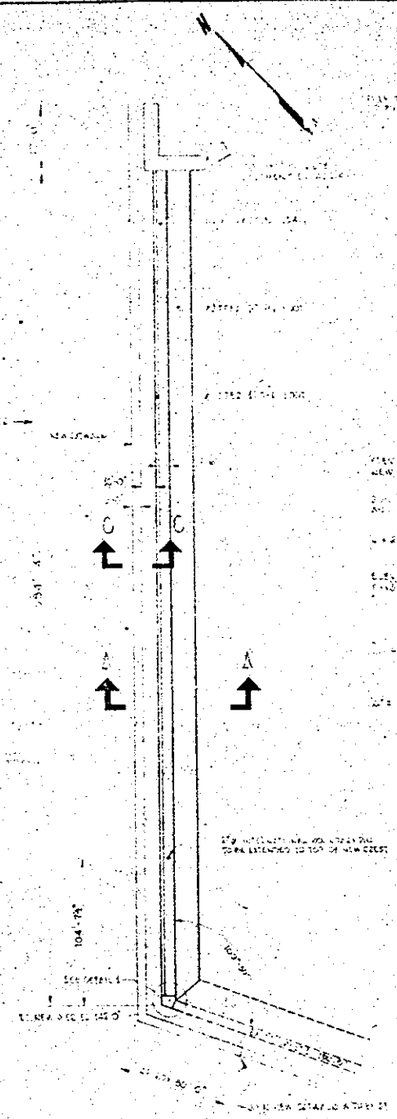
THE MINIMUM TOP WIDTH RECOMMENDED IS 4' TO RESIST SHOCK FROM FLOATING OBJECTS. IF A DAM OF 10' HEIGHT IS DESIRED, THE UPPER HALF OF THE PROFILE WOULD BE USED.

265' IS THE MAXIMUM ALLOWABLE HEIGHT FOR THIS PROFILE.

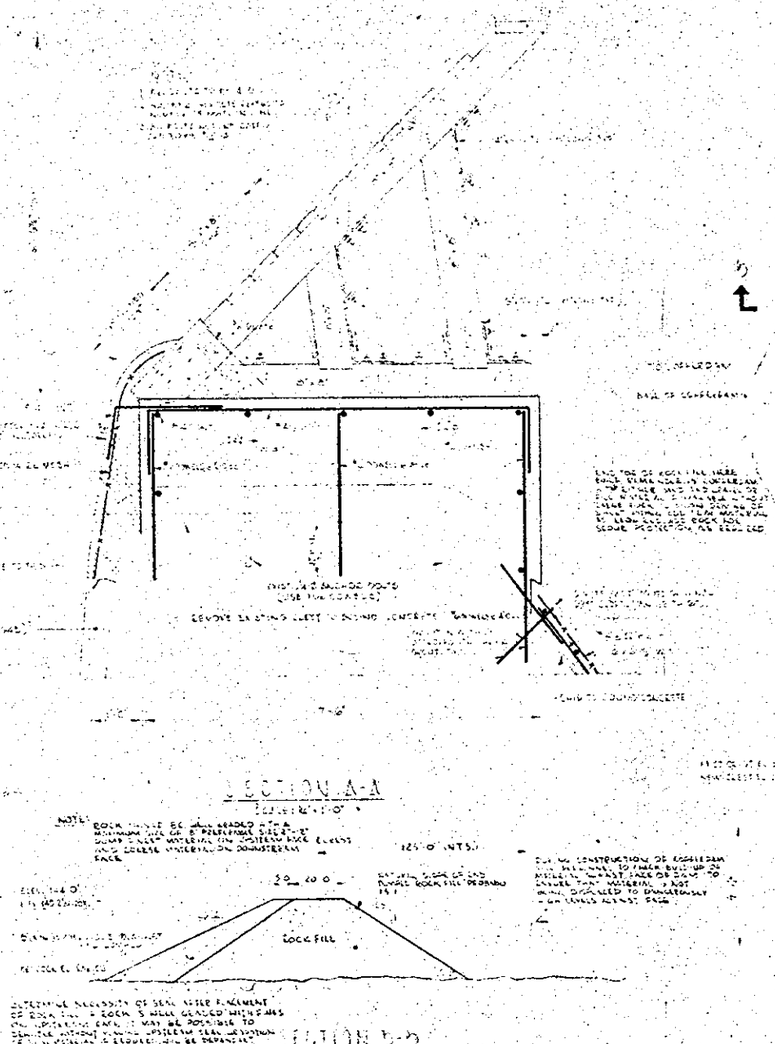
ALL PRESSURE LINES FALL IN MIDDLE THIRD, RESEVOIR FULL OR EMPTY. SLIDING WILL NOT OCCUR AT ANY HORIZONTAL PLANE IN PROFILE.

FACTOR OF SAFTEY AGAINST OVERTURNING IS AT LEAST 2.0.

ST CROIX PAPER CO.
WOODLAND MAINE
TITLE: GRAVITY DAM
LOCATION
SCALE AS NOTED
DRAWN BY
CHECKED BY
APPR.

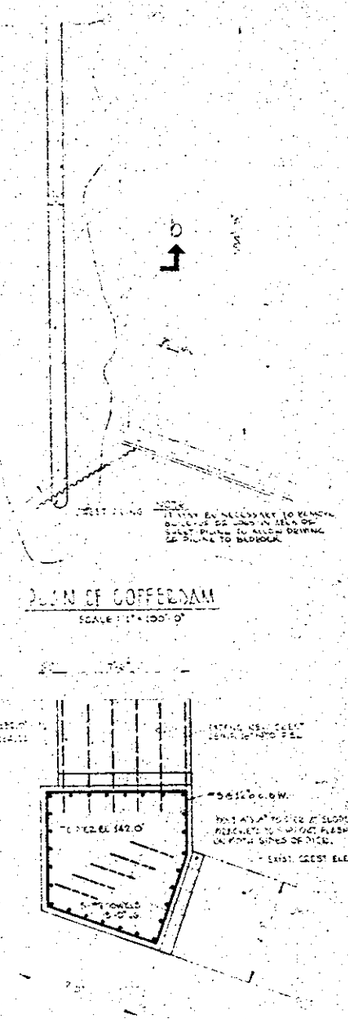


PLAN OF DAM (CONCRETE SPILLWAY)



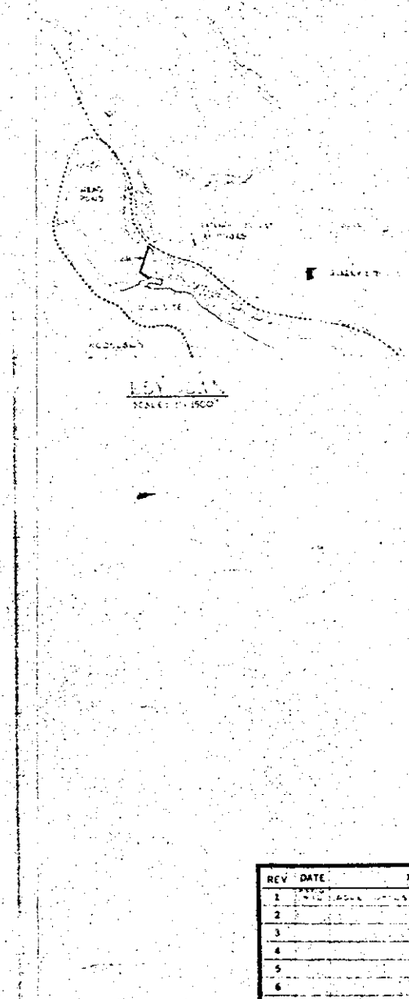
SECTION A-A

SECTION B-B



PLAN OF COFFERDAM

DETAIL 1



REV	DATE	REVISIONS	DRN	CHK'D	APP'D
1					
2					
3					
4					
5					
6					
7					
8					

GEORGIA-PACIFIC
THE GROWTH COMPANY

DIVISION
WOODLAND, MAINE

CONSULTANT
NEILL AND GUNTER LIMITED

TITLE

APP. NO. PROJECT NO.

SCALE DATE DRAWING NO. REV

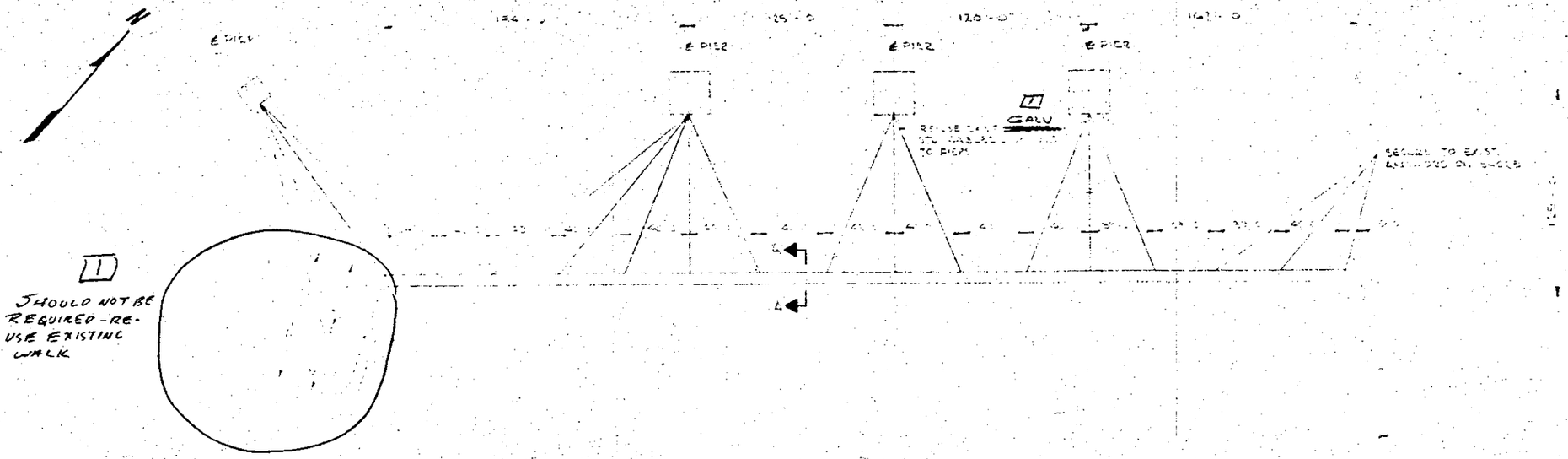
DRAWN

CHECKED

APPROVED

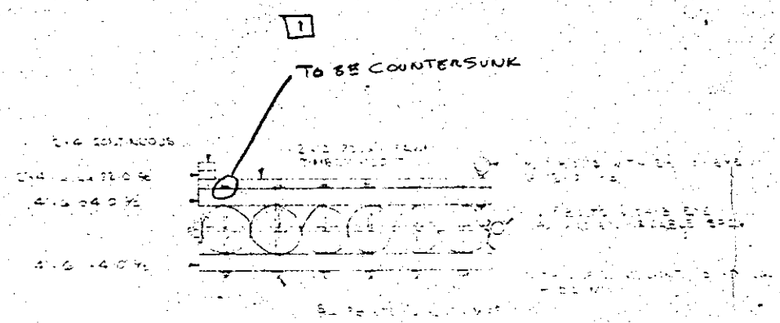
APPROVED

DISTRIBUTION



PLAN OF CATWALK

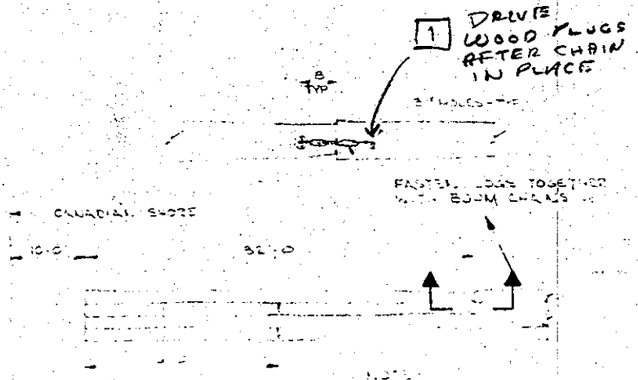
SCALE: 1" = 50'-0"



SECTION A-A

TYP. CATWALK SECTION

SCALE: NONE



PLAN

TYP. LOG ARRANGEMENT

1 NOTE: ALL FASTENERS EXCEPT 1" BOLTS WITH 3" EYE & BOOM CHAINS TO BE GALV.

BOOM CHAINS TO BE SUPPLIED BY G-P IF NOT READILY AVAILABLE TO CONTRACTOR

REV.	DATE	REVISIONS	DRN.	CH'D.	AP'D.
1	6/14/79	MAT'LS & MINOR DESIGN CHGS	UD		
2					
3					
4					
5					
6					
7					
8					

GEORGIA-PACIFIC
THE GROWTH COMPANY

DIVISION: WOODLAND, MAINE

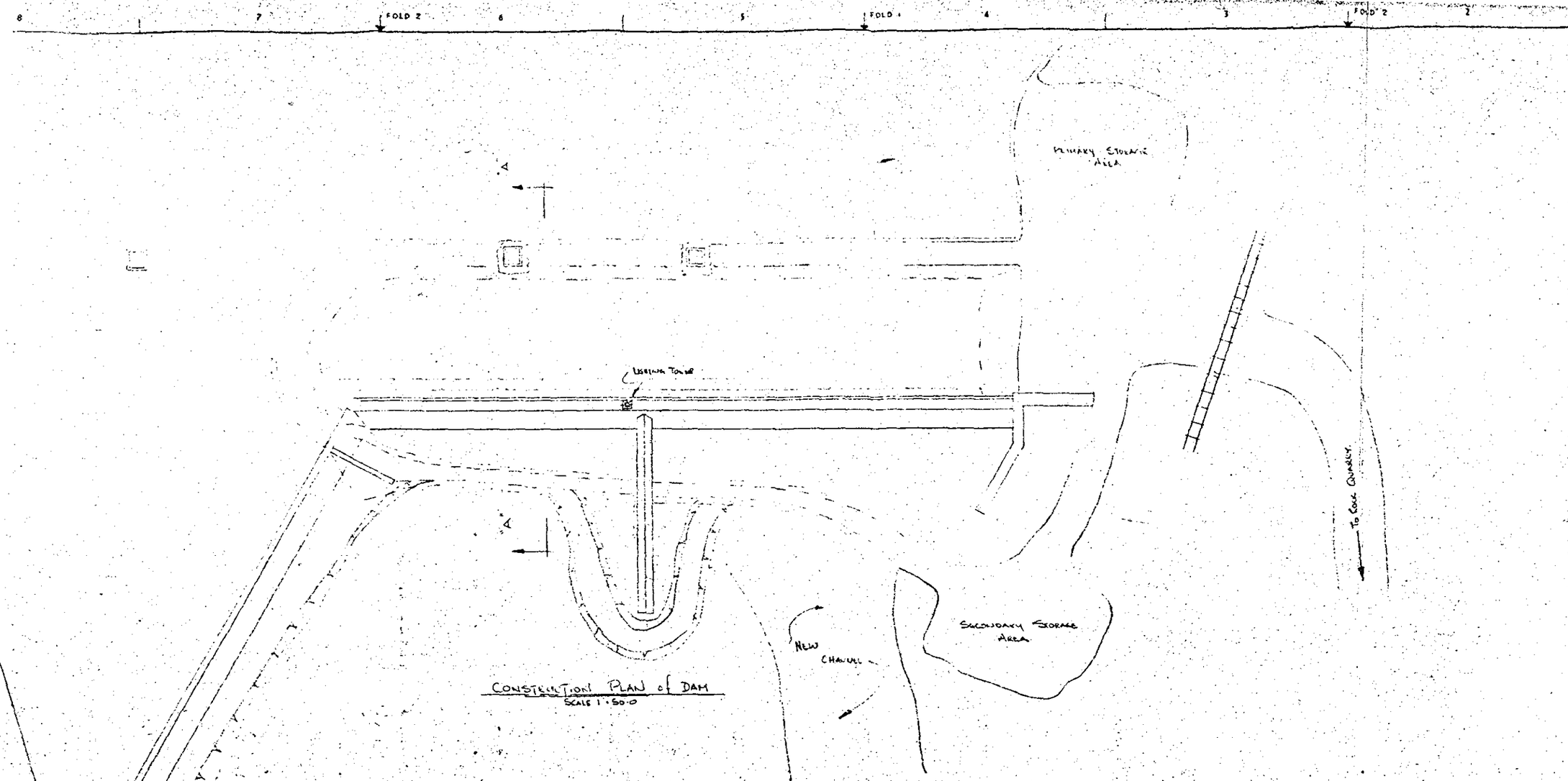
CONSULTANT: [illegible] LIMITED
FREDERICTON, N.B. HALIFAX, N.S.

TITLE: WOOD [illegible] REPAIRS
CATWALK DETAILS

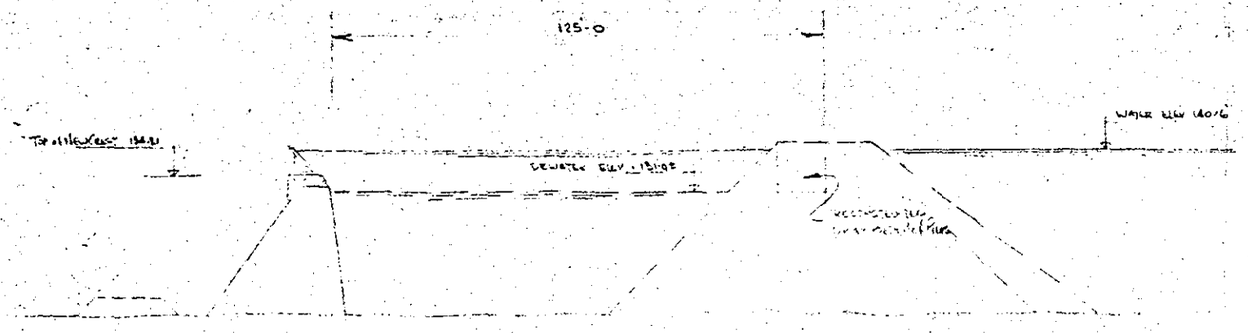
AFE NO. | PROJECT NO.

SCALE: AS NOTED	DATE	DRAWING NO.	REV.
DRAWN: UFC		9-624	1
CHECKED:			
APPROVED:			
APPROVED: P.L. 6/14/79		C9564-0513	

DISTRIBUTION:



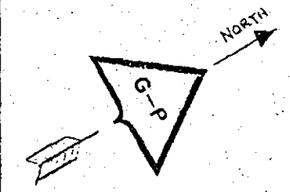
CONSTRUCTION PLAN of DAM
SCALE 1:50-0



SECTION A-A
SCALE 1:50-0

REFERENCE

DWG NO.	DESCRIPTION	NO



NO	DESCRIPTION	DATE	APP.
	REVISIONS		

DRAWN	
CHECKED	
APP'D	
DATE	JAN 3, 1973
SCALE:	As Noted

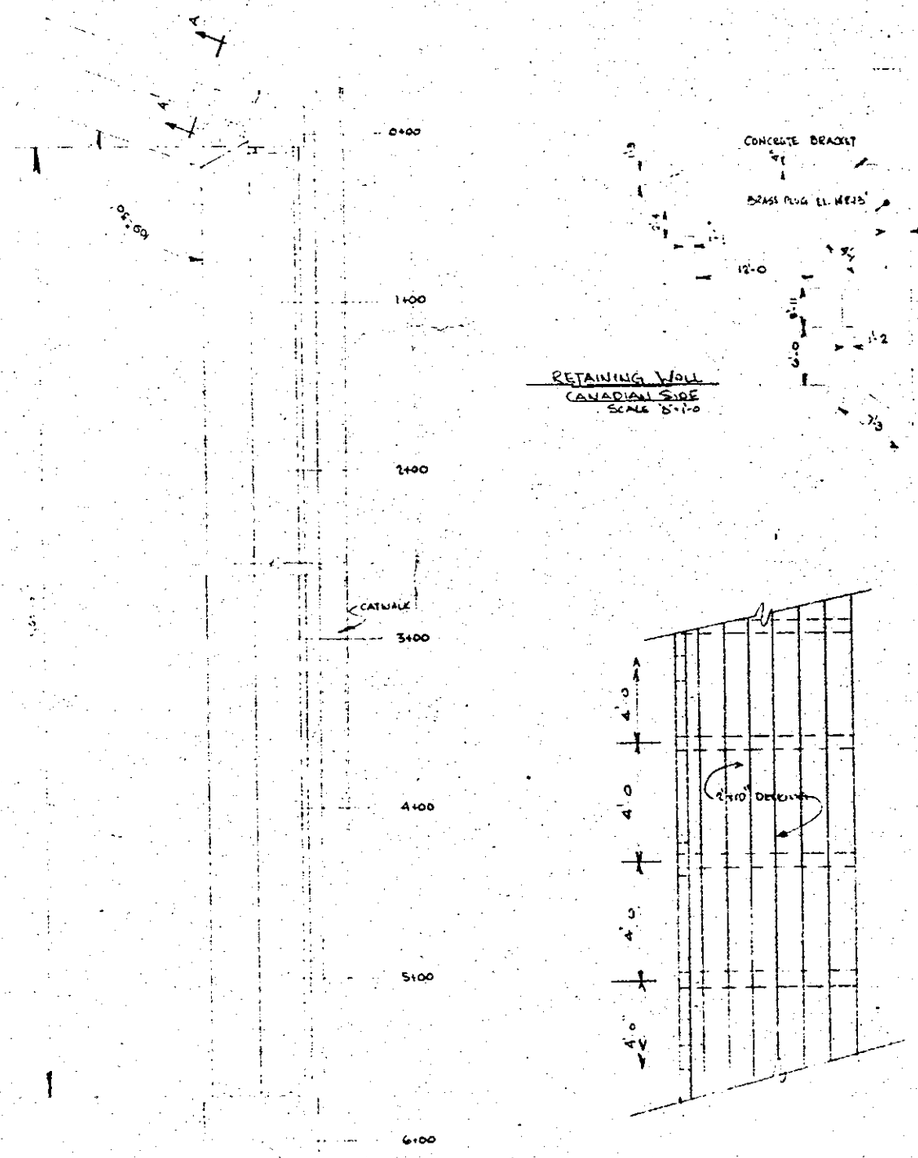
ATLAS CONSTRUCTION MARITIMES LIMITED
PO BOX 7 DOAK ROAD FREDERICTON N.B

DAM REPAIRS
GEORGIA PACIFIC

AS CONSTRUCTED
PLAN
of DAM SITE

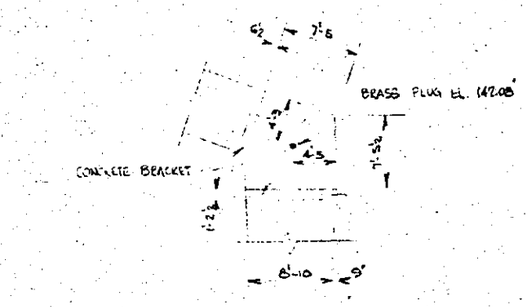
DWG. NO. C-102-S
REV. 0

D5441-05-2

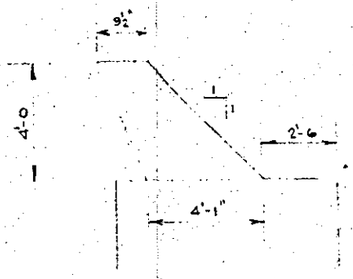


PLAN of DAM
SCALE 1"=1'-0

RETAINING WALL
CANADIAN SIDE
SCALE 1/8"=1'-0

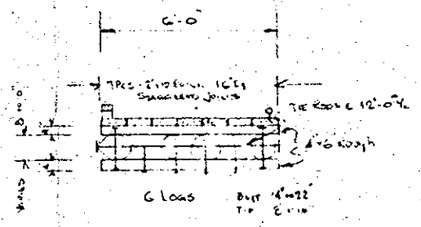


CORNER PIER DETAIL
SCALE 1/8"=1'-0



SECTION "A-A"
SCALE 1/8"=1'-0

PARTIAL PLAN of CATWALK



TYPICAL SECTION THRU CATWALK

SCHEDULE OF CREST POURS

RUN #	DATE	QUANTITY	STATIONS
1	AUG 30	27 YDS	0+32 TO 0+44
2	SEPT 1	61 "	0+56 TO 1+44
3	"	78 "	0+50 + 0+44 TO 2+68
4	8	78 "	1+44 TO 2+68
5	11	77 "	2+68 TO 3+72
6	4	54 "	3+72 + 3+84 TO 4+26
7	6	28 "	3+72 TO 3+84
8	20	77 "	4+26 TO 4+80 *
9	22	70 "	4+26 TO 5+44
10	20	48.5 "	5+44 TO END
TOTAL		624.5 YDS	

* INCLUDES BREAKER APRON SIDE

REFERENCE		
DWG NO.	DESCRIPTION	NO

NO	DESCRIPTION	DATE APP
	REVISIONS	

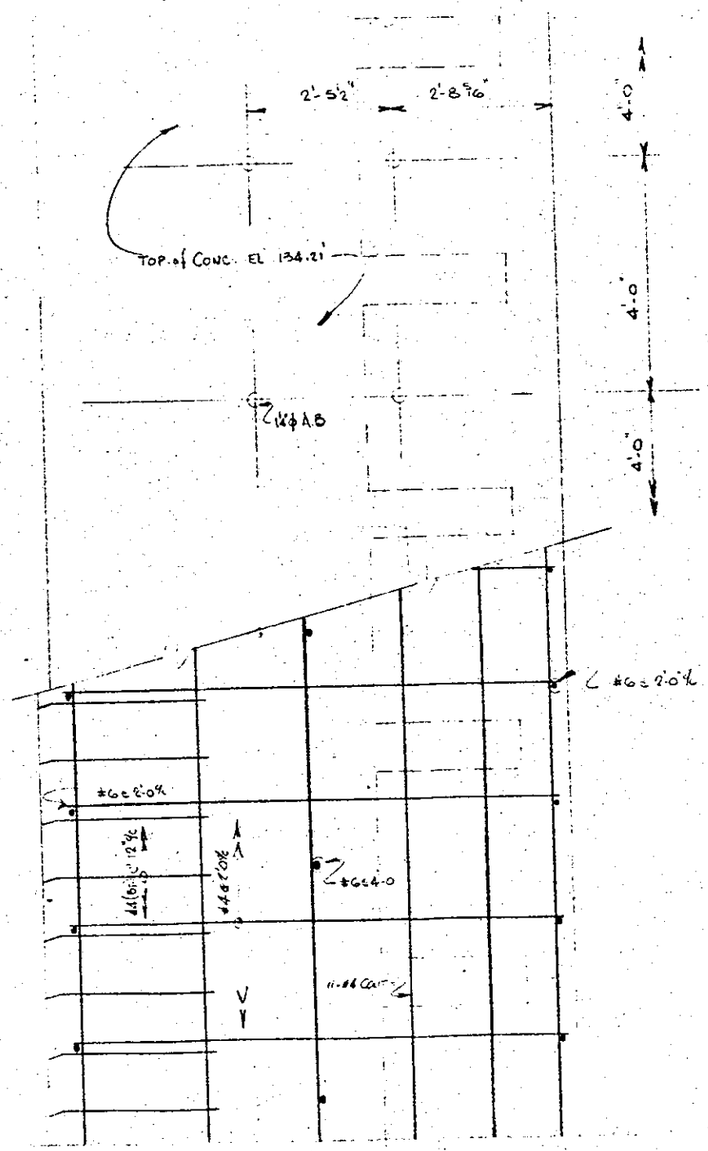
DRAWN	[illegible]
CHECKED	
APP'D	
DATE	OCT 25,72
SCALE: AS NOTED	

ATLAS CONSTRUCTION MARITIMES LIMITED
P.O. BOX 7 DOAK ROAD FREDERICTON N.B.

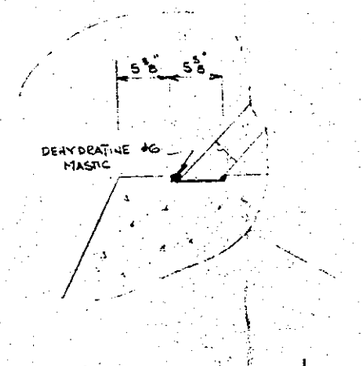
DAM REPAIRS
GEORGIA PACIFIC

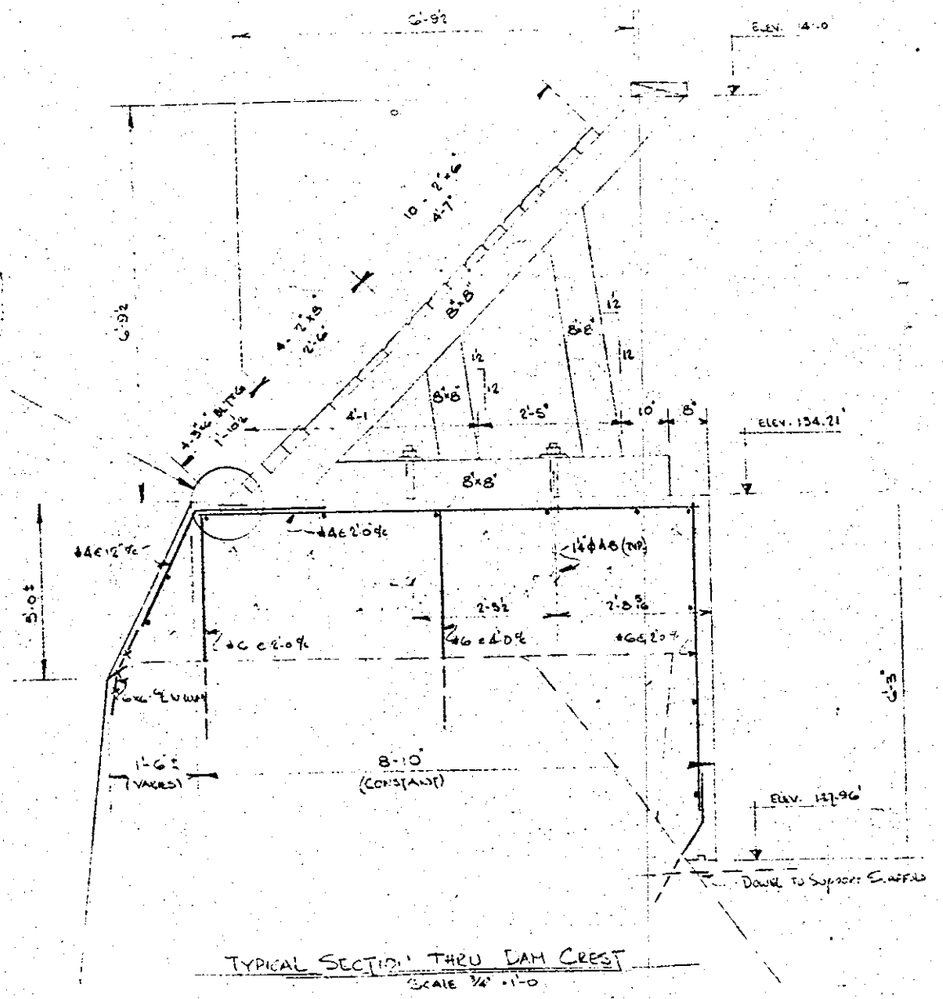
AS CONSTRUCTED
DETAILS
&
SCHEDULE of CREST POURS

DWG. NO. C-1762-6
REV 0



PARTIAL PLAN of REPAIR & ANCHOR BOLT LAYOUT
SCALE ¾" = 1'-0"





TYPICAL SECTION THRU DAM CREST
SCALE ¾" = 1'-0"

REFERENCE

DWG NO.	DESCRIPTION	NO

NOTES

1. ALL WOODEN BRACKETS ARE 8"x8" B.C. FIR CEED.
2. ALL LUMBER FOR SPLASH BOARDS - CONST. GRADE #1 SPRUCE
3. ALL STEEL CONNECTORS ARE A36 STEEL GAL COATED
4. CONCRETE 4000 P.S.I. CEMENT CONTENT 600 #/yd³
5. TOP OF CONCRETE ON CREST HAS STEEL TROWEL FINISH

NO.	DESCRIPTION	DATE APP.
	REVISIONS	

DRAWN	B. Tucker
CHECKED	
APP'D	
DATE	OCT 23.72
SCALE:	AS NOTED

ATLAS CONSTRUCTION MARITIMES LIMITED
PO BOX 7 OAK ROAD FREDERICTON N.B.

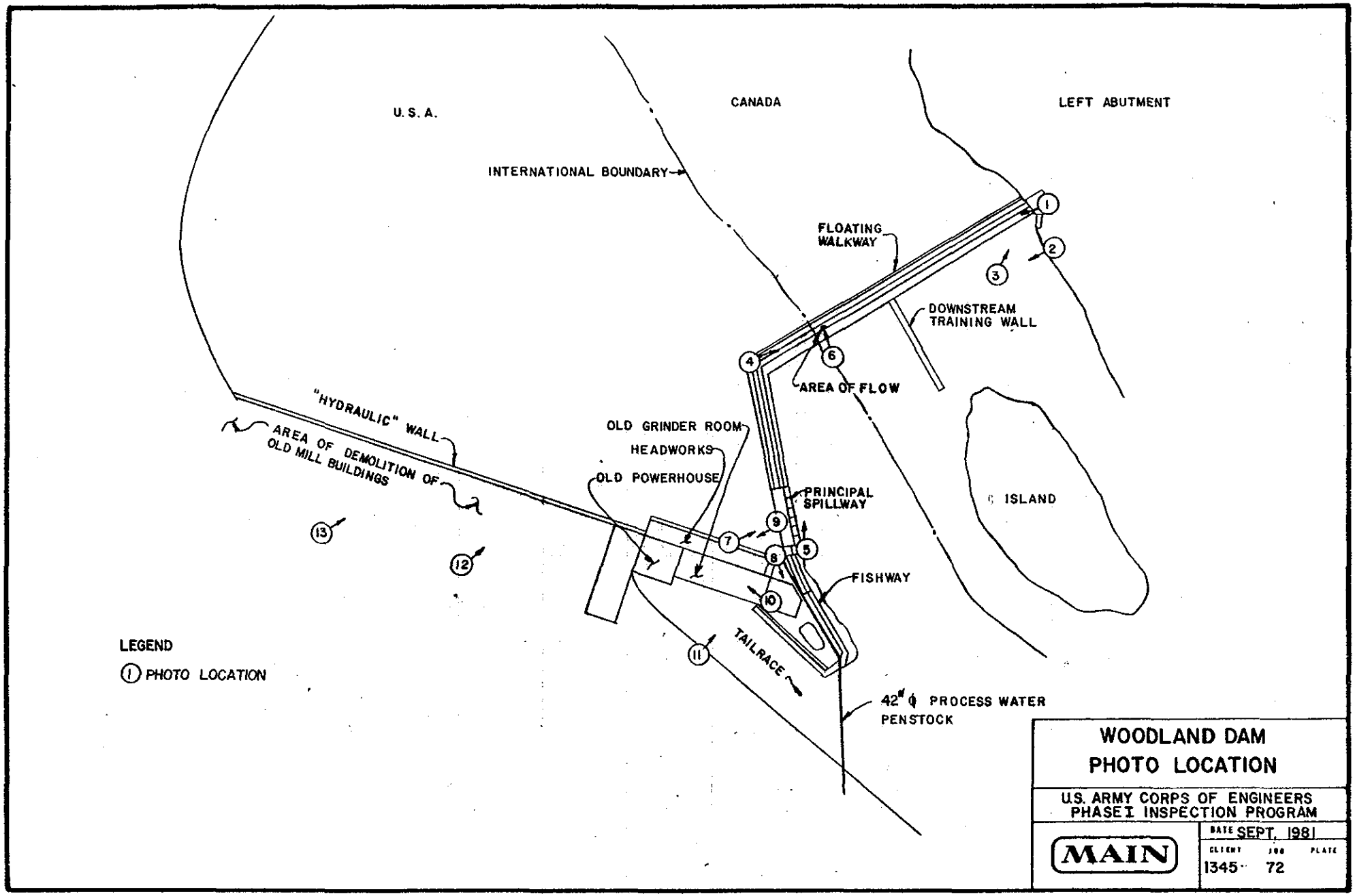
DAM REPAIRS
GEORGIA PACIFIC

AS CONSTRUCTED DETAILS of CREST CONCRETE

DWG. NO.	REV.
C-1762-7	0

D8564-2059

APPENDIX C - PHOTOGRAPHS


U.S.A.
CANADA
LEFT ABUTMENT
INTERNATIONAL BOUNDARY
FLOATING WALKWAY
DOWNSTREAM TRAINING WALL
AREA OF FLOW
"HYDRAULIC" WALL
AREA OF DEMOLITION OF OLD MILL BUILDINGS
OLD GRINDER ROOM
HEADWORKS
OLD POWERHOUSE
PRINCIPAL SPILLWAY
ISLAND
FISHWAY
TAILRACE
42" ϕ PROCESS WATER PENSTOCK
LEGEND
(1) PHOTO LOCATION
WOODLAND DAM
PHOTO LOCATION
U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM
MAIN
DATE SEPT. 1981
CLIENT 1345
JOB 72
PLATE

No. 2
Downstream face of Canadian spillway from left abutment area.

No. 3
Left abutment from downstream.

No. 4
View Across crest of Canadian spillway from corner pier.

No. 5
Downstream slope of Canadian spillway from dam crest at the fishway.

No. 6
Flow at downstream toe of Canadian spillway.

No. 7
View of tainter gates from the headworks.

No. 8
View downstream from dam at the process water gatehouse.

No. 9
Headworks from the catwalk at the principal spillway.

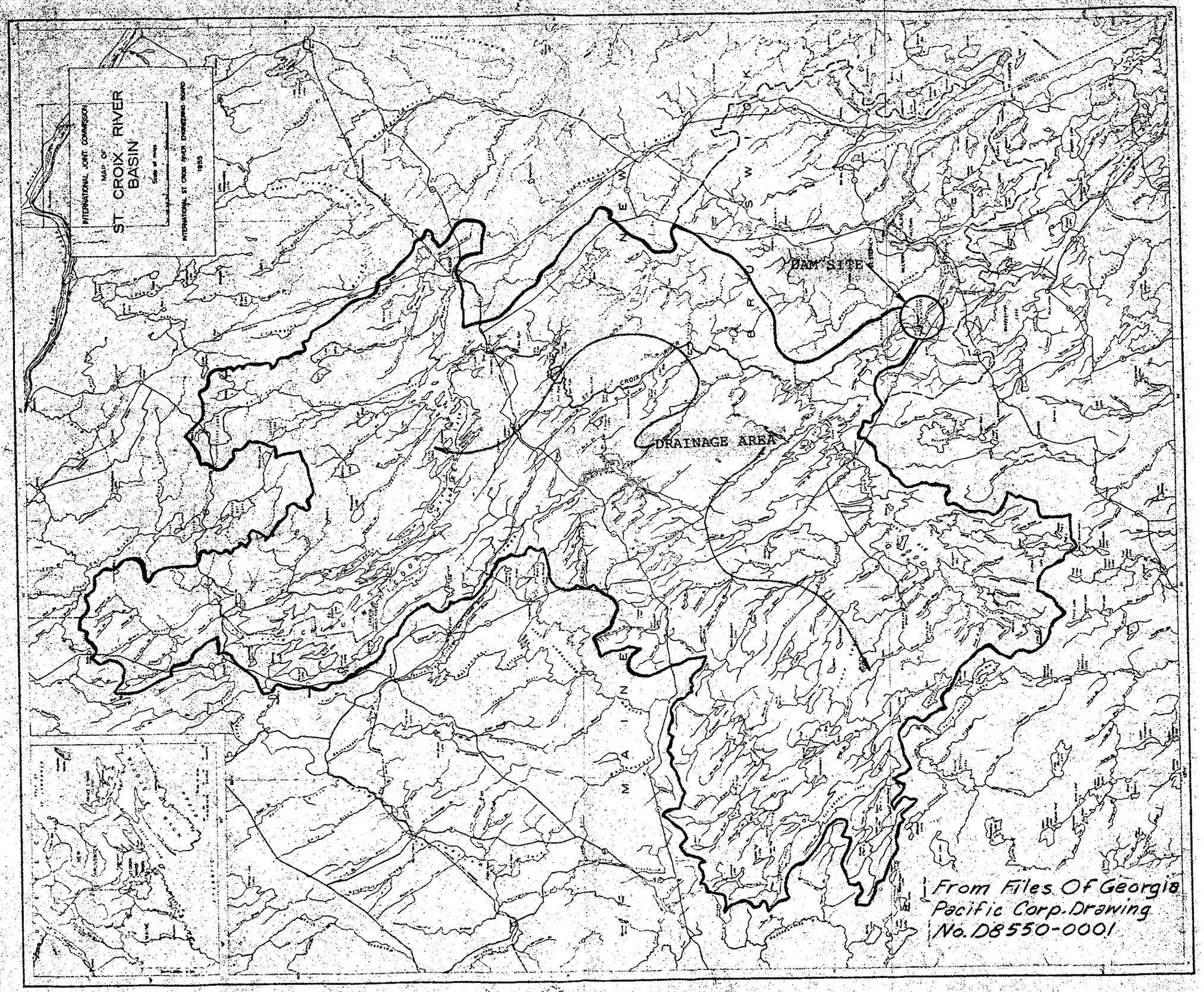
No. 10
View of the
headworks wall
above the old
grinder room.

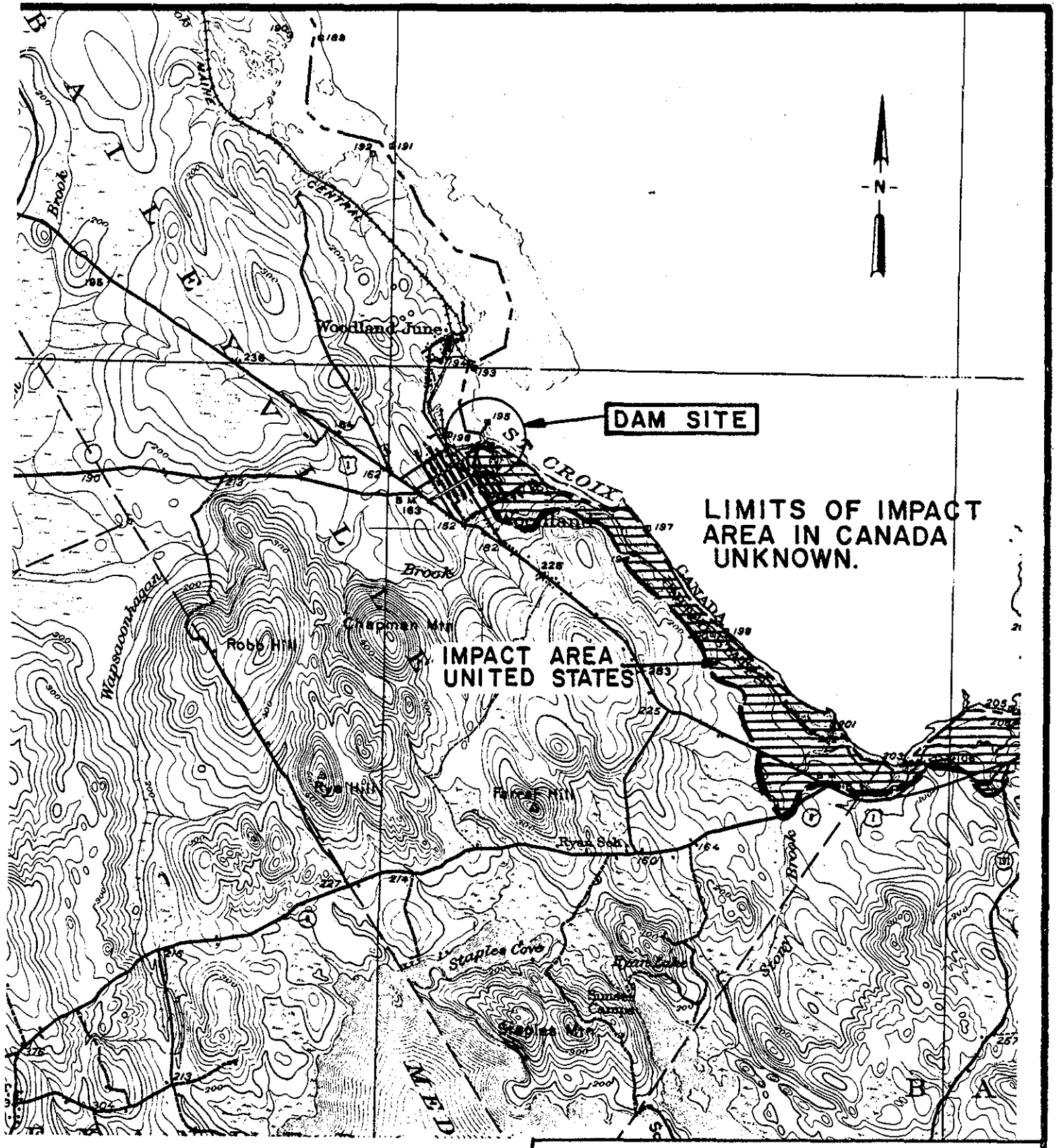
No. 11
Downstream face
of the powerhouse.

No. 12
Downstream face
of the hydraulic
wall.

No. 13
Downstream face
of the hydraulic
wall.

APPENDIX D - HYDRAULIC AND HYDROLOGIC COMPUTATIONS


MAP OF
ST. CROIX RIVER
BASIN
Scale of miles
INTERNATIONAL JOINT COMMISSION
INTERNATIONAL ST. CROIX RIVER ENGINEERING BOARD
1953
DAM SITE
DRAINAGE AREA
ST. CROIX
From Files Of Georgia
Pacific Corp. Drawing
No. D8550-0001



FROM: USGS CALAIS, ME.
15 MIN. QUADRANGLE MAP

0

SCALE: 1" = 1 MILE

WOODLAND DAM
LOCATION MAP

U.S. ARMY CORPS OF ENGINEERS
PHASE I INSPECTION PROGRAM

DATE SEPT. 1981

MAIN

CLIENT 1345 | JOB 72 | PLATE

MAIN

Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 1 of 13
Subject WOODLAND DAM By T. OTOVA Date 09-11-81
HYDROLOGY — HYDRAULICS Ckd. Rev.

DRAINAGE AREA = 1350 sq. mi.

For flat & coastal terrain PMF curves (Corps of Engineers Guidelines, March 1978), yield 50 cfs/sq. mi. peak discharge.
The total peak discharge = 50 × 1350 = 67500 cfs.
The guideline curves are derived for 19" runoff. In this part of New England, Maine, Depth-Area-Duration curves show a 13" of runoff and this is confirmed by Corps of Engineers.
Then, test flood is assumed to be equal to PMF which is,

$$Q_{test} = 67500 \times \frac{13"}{19"} = 46184 \text{ cfs.}$$

The emergency and sprincipal spillways are sharp crested weirs with crest elevations 134 and 136 ft, respectively. Their rating curves are illustrated in pages 6 and 7. The flood routing starting elevation is selected to be 136 ft and the combined rating curve used in flood routing is shown in page 8.
The Area-Capacity curves are estimated from 1:62500 scale topographic maps and by using

logarithmic curve fitting procedure (page 3 & 4).
The Area - Capacity curves are presented in page 5.
The effects of surcharge storage on maximum probable discharges are estimated according to Corps of Engineers procedure presented in the previous pages.

Results:

Averaged Discharge 46100 cfs.
Water Surface Elev. 140.00 (ft)
Surcharge Height 6.0 (ft)
Crest Elev. of the Dam 142.21 (ft)
Volume at Dam Crest Elev. 4379.86 (ac-ft)
Volume at Max. Water Surface El. 1780.0 (ac-ft)

The dam will not be overtopped.

Client CORPS OF ENGINEERS Job No. 134C-072 Sheet 3 of 13
Subject WOODLAND DAM By T. OTOYA Date 09-10-91
HYDROLOGY – HYDRAULICS Ckd. Rev.

CORPS OF ENGINEERS

WOODLAND
~~GRAND LAKE~~ RES.AREA CURVE

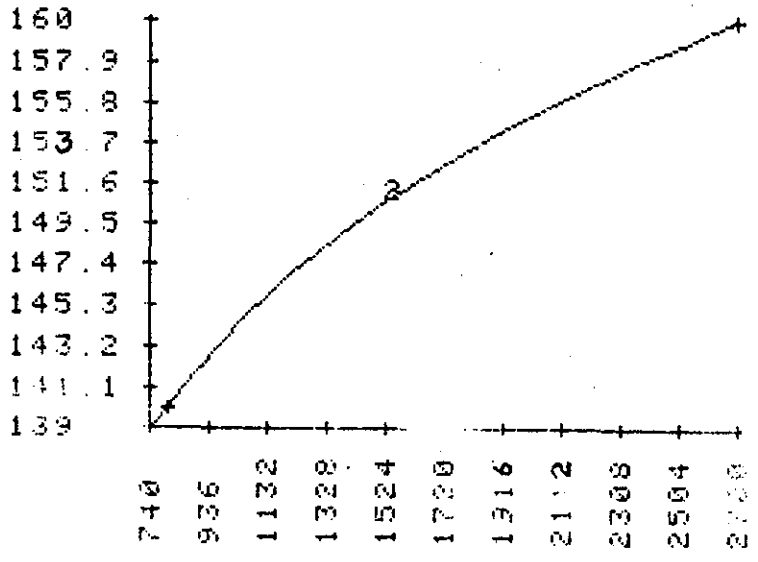
I	X(I)	Y(I)
1	740.0000	139.0000
2	800.0000	140.0000
3	2700.0000	160.0000

AOV: LOG REG:CODE 2

SOURCE	DF	SS	MS	F
TOTAL	2	280.7		
REG	1	280.6	280.6	999.9
RESID	1	0.0	0.0	

R SQUARE = 1.000

YHAT= 31.050+ 16.320LOG X



Client CORPS OF ENGINEERS Job No. 1361-072 Sheet 4 of 13

Subject WOODLAND RESERVOIR By T. DOUGA Date 09-10-81

HYDROLOGY - HYDRAULICS Ckd. Rev.

CORPS OF ENGINEERS

WOODLAND

~~GRAND LAKE~~ RES.CAPACITY CURVE

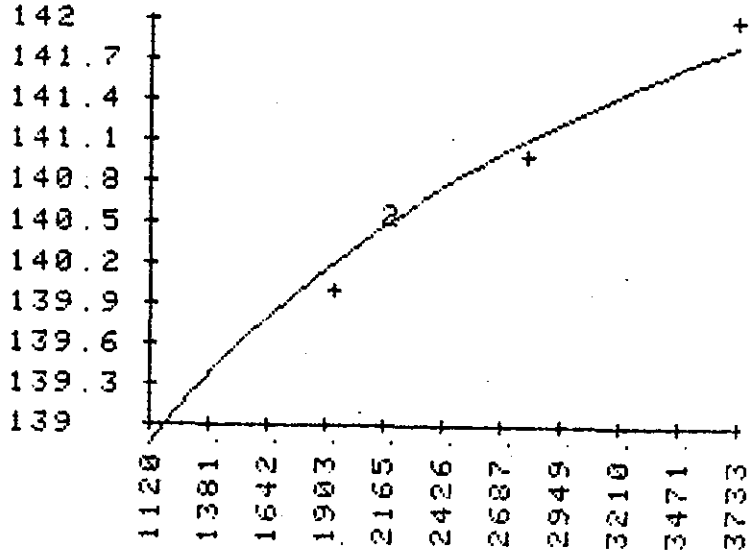
I	X(I)	Y(I)
1	1120.0000	139.0000
2	1938.0000	140.0000
3	2808.0000	141.0000
4	3733.0000	142.0000

AOV: LOG REG:CODE 2

SOURCE/DF		SS	MS	F
TOTAL	3	5.0		
REG	1	4.9	4.9	89.2
RESID	2	0.1	0.1	

R SQUARE = 0.978

YHAT= 121.617+ 2.456LOG X

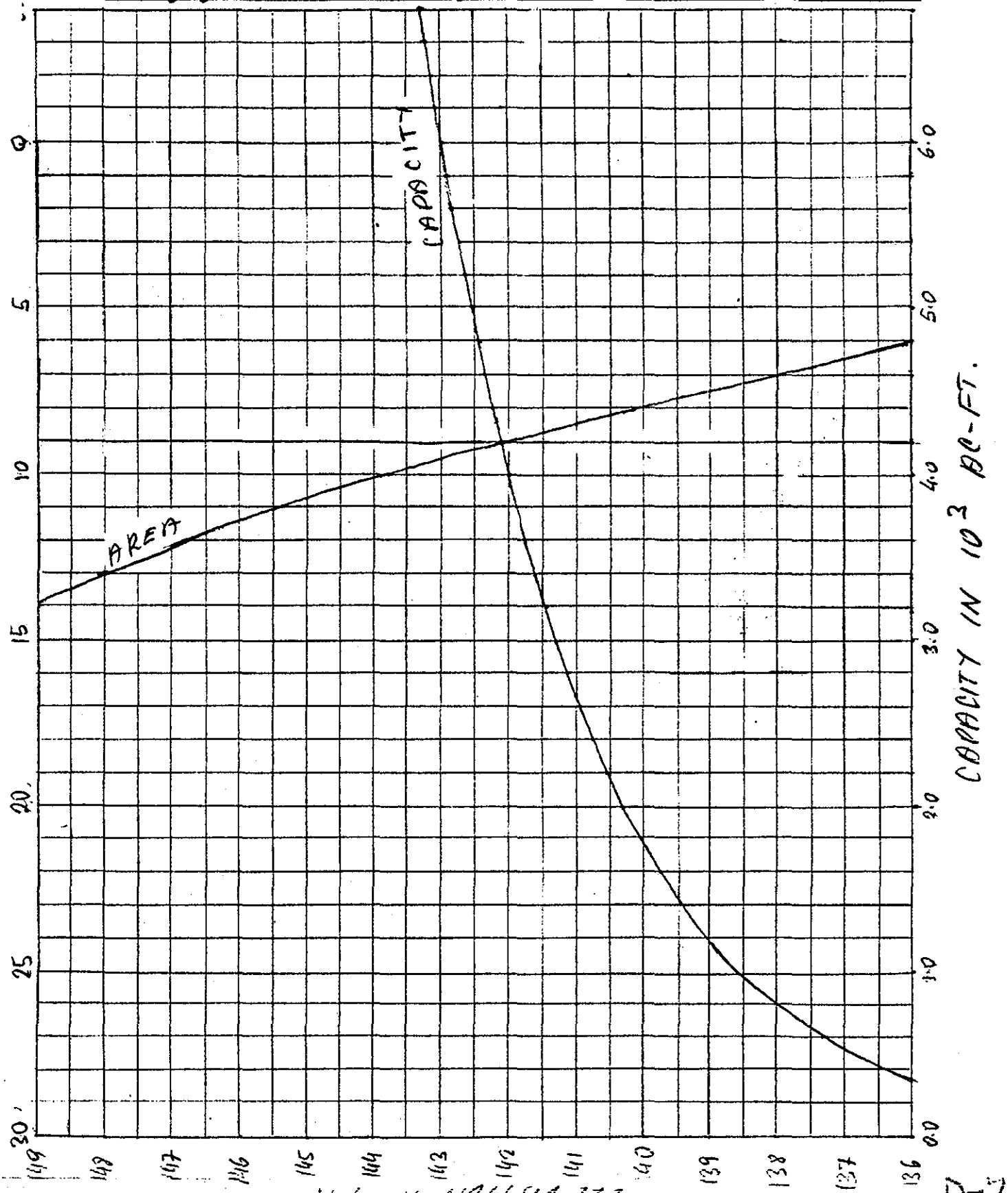


MAIN

Client CORPS OF ENGINEERS Job No. 1345-077 Sheet 5 of 13

Subject WOODLAND DAM By T.O'FOUR Date 09-11-81

HYDROLOGY - HYDRAULICS Ckd. Rev.



D-7

$$Q = 3.7 \times (12.5 \times 5) \times H^{3/2}$$

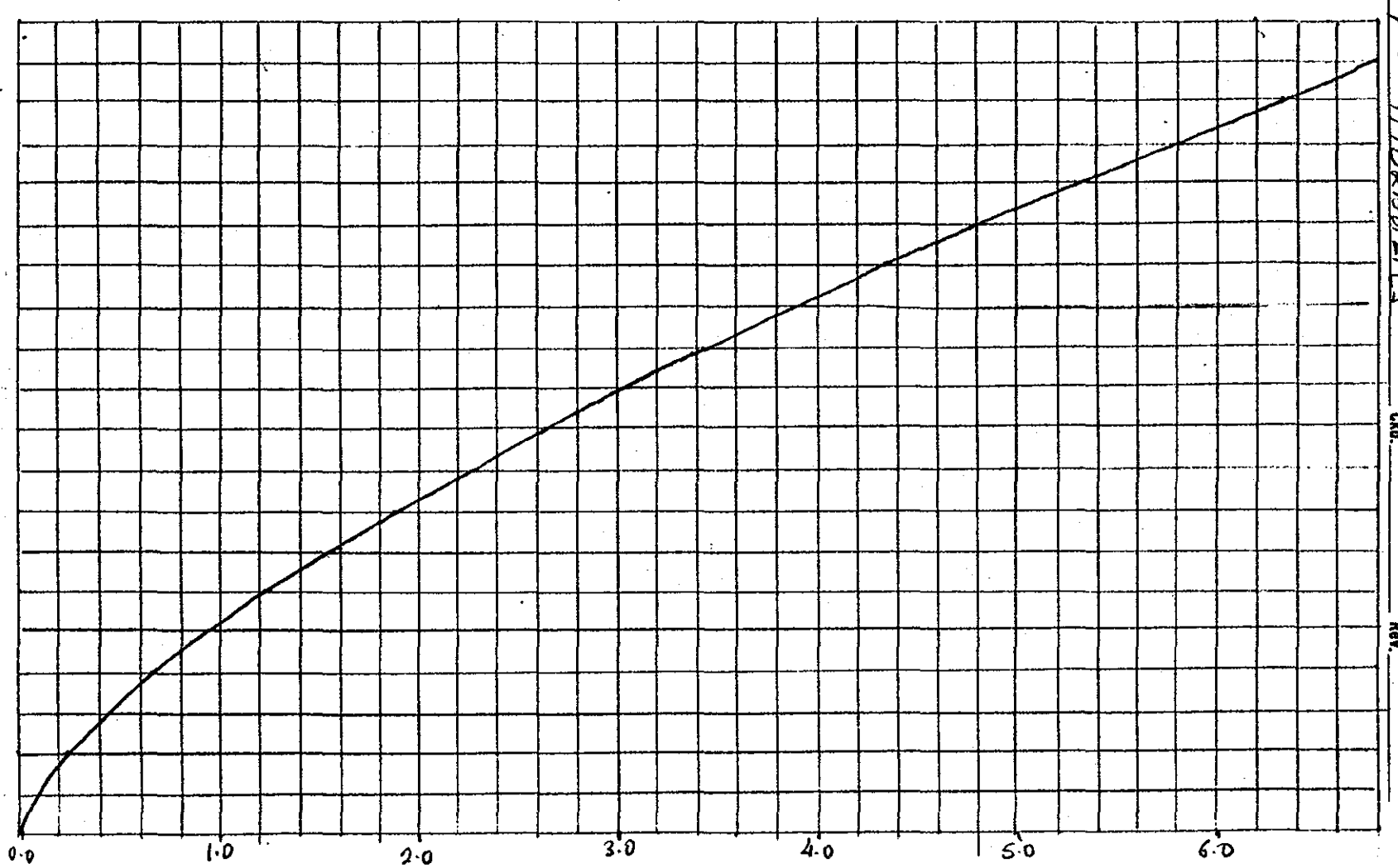
Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 6 of 13

Subject WOODLAND DAM By T. OTOVA Date 09-11-81

HYDROLOGY - HYDRAULICS Ckd. Rev.

MAIN

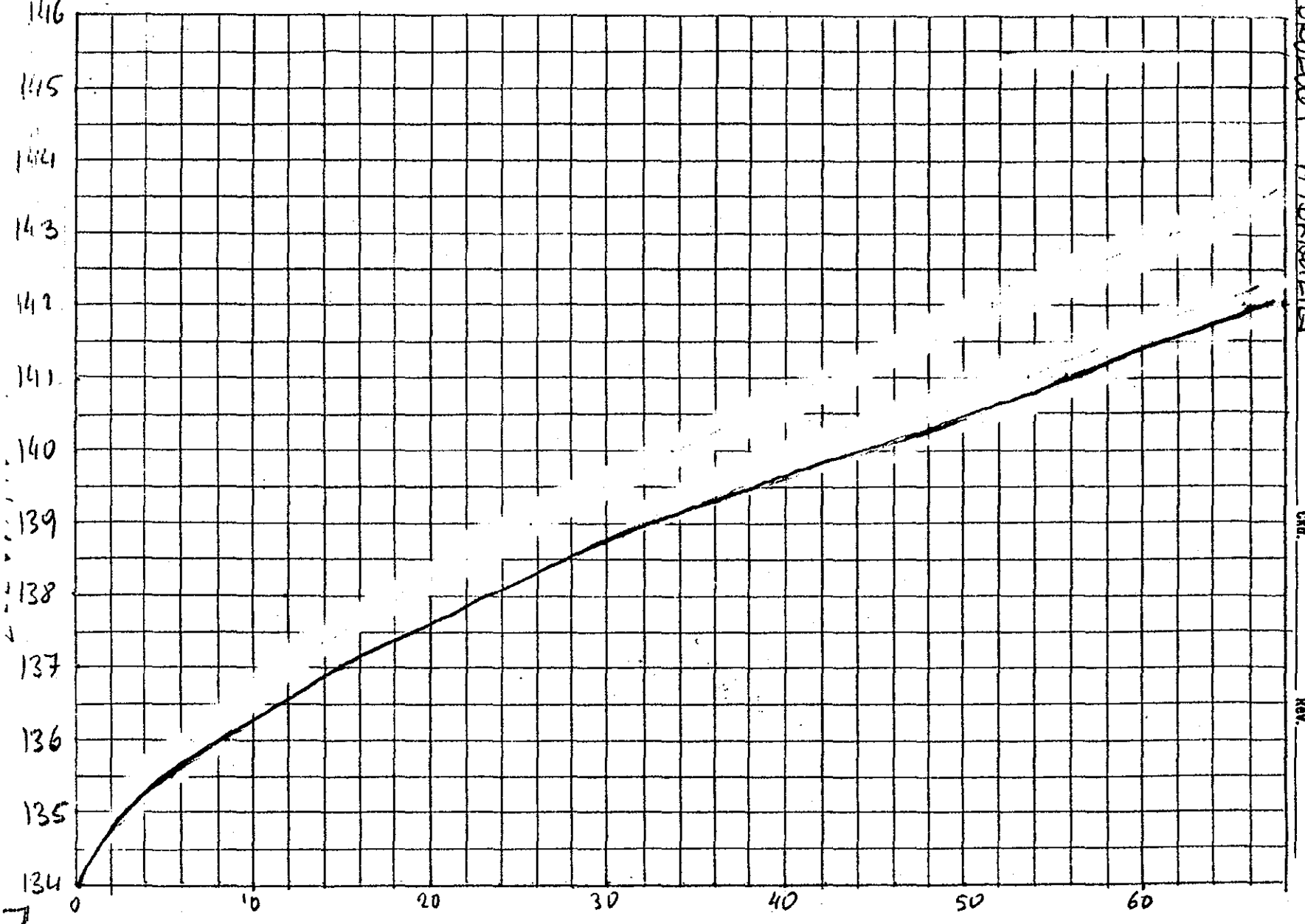
TENDER GATES RATING CURVE
(PRINCIPAL SPILLWAY)



D-00

$C' = 3.7 \times (TBD) \times 11$

EMERGENCY SPILLWAY RATING CURVE
(Flash Boards)



Client CORPS OF ENGINEERS Job No. 345-072 Sheet 7 of 13

Subject WOODLAND DAM By T.OTOVA Date 09-11-81

HYDROLOGY - HYDRAULICS Chd. Rev.

MAIN

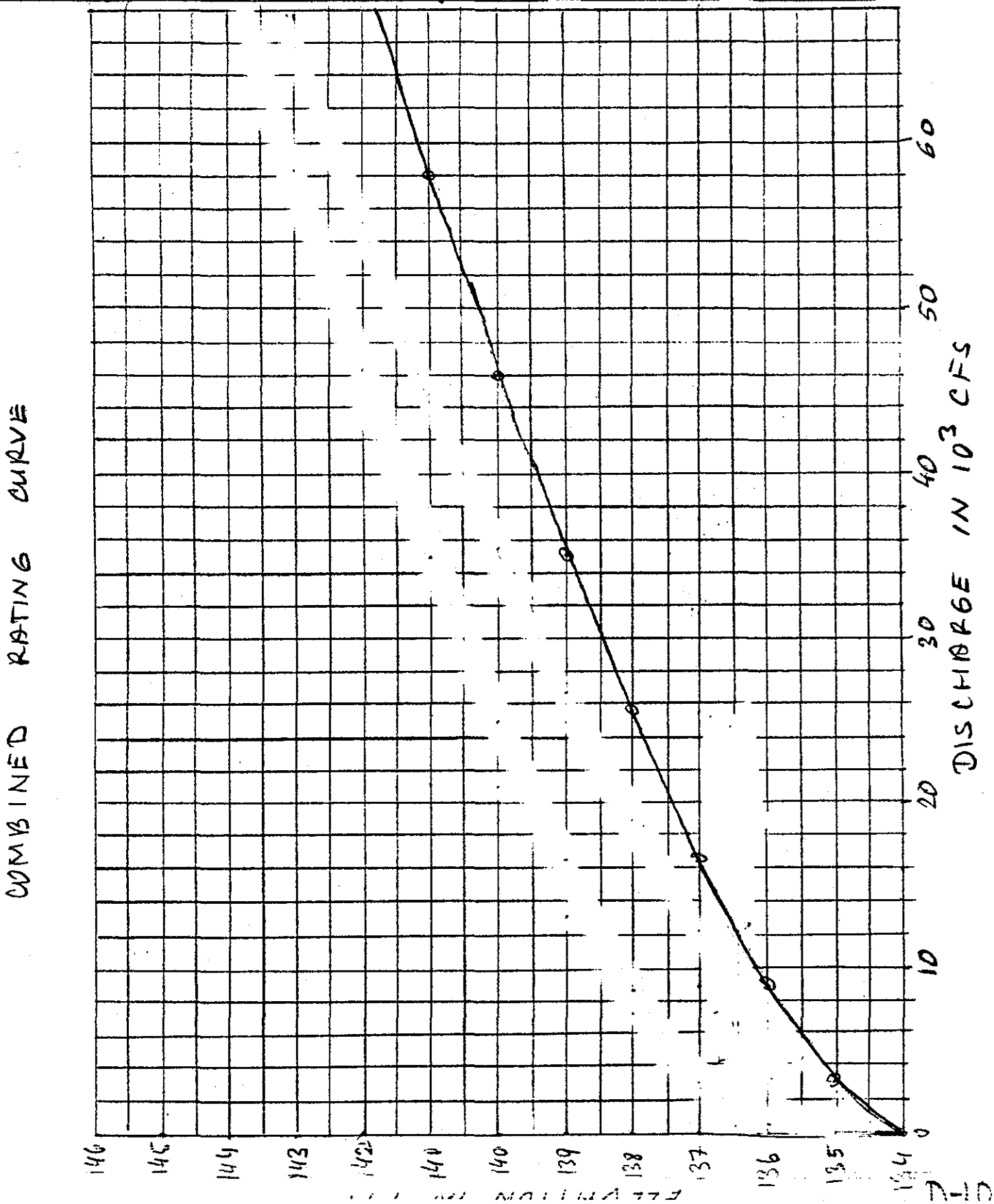
D-40

MAIN

Client CORPS OF ENGINEERS Job No. 1345-07 Sheet 8 of 13

Subject WOODLAND - DAM By T. OTOVA Date 09-IX-81

HYDROLOGY - HYDRAULICS Ckd. Rev.



Client CORPS OF ENGINEERS Job No. 1345-077 Sheet 9 of 13
Subject WOODLAND DAM By T. OTOYA Date 09-10-81
HYDROLOGY - HYDRAULICS

ESTIMATING
EFFECT OF SURCHARGE STORAGE
ON MAXIMUM PROBABLE DISCHARGES

These calculations are performed according to the Corps of Engineers Guidelines

WOODLAND DAM DAM

D A T A :

DRAINAGE AREA,
A= 1350 (sq.mi.)

PEAK INFLOW,
Qp1= 46180 (cfs)

PRINCIPAL SPILLWAY CREST ELEV.,
ELV1= 134 (ft.)

EMERGENCY SPILLWAY CREST ELEV.,
ELV2= 134 (ft.)

Emergency Spillway Rating Curve is defined as ,

H = a * Q ^ b

a = .004666
b = .666667

The Capacity - Elv. curve is defined as,

Elv = m + n * Log(Volume)

m= 121.617
n= 2.456

TOTAL PMF RUNOFF,
R= 13 (in.)

CALCULATIONS:

S T E P 1

Reduction of the Qp1 due to starting elevation at Principal Spillway crest elev.

Volume at 134 (ft.)

Volume1 =Exp((ELV1-m)/n)
Volume1 = 154.769 (ac-ft)

Volume at 134 (ft.)

Volume2 =Exp((ELV2-m)/n)
Volume2 = 154.769 (ac-ft)

Diff. of Volumes,

Diff.Volume = 0 (ac-ft)
or,
Diff.Volume, D= 0 (in.)

NEW Qp1=Qp1*(1-D/R)
NEW Qp1 = 46180 (cfs)

S T E P 2

Surcharge Height,

H = a * Qp1 ^ b
H = 6 (ft.)

Surcharge Volume,

ELV=ELV2 + H
ELV= 140 (ft.)

Volume = 1785.333 (ac-ft)

STOR1 =Volume - Volume2

STOR1 = 1630 563 (ac-ft)
or,
STOR1 = .02 (in.)

Client CORPS OF ENGINEERS Job No. 1345-072-4 Sheet 10 of 13
Project WOODLAND DAM By J.D TOUMA Date 09-10-92
Ckd. Rev.

Corresponding Discharge,

Qp2 = Qp1*(1-STOR1/R)
Qp2 = 46099 (cfs)

S T E P 3

Surcharge Height,

H = a * Qp2 ^ b
H = 5.99 (ft.)

Surcharge Volume,STOR2,

ELV = ELV2 + H
ELV = 139.99 (ft.)

Volume = 1780.268 (ac-ft)

Diff.Volume = Volume - Volume2
Diff.Volume = 1625.499 (ac-ft)
or
STOR2 = .02 (in.)

OLD STOR.AVE.= (STOR1 + STOR2) / 2
OLD STOR.AVE. = .02 (in.)

Qp3 =Qp1*(1 - OLD STO.AVE. / R)
Qp3 = 46099 (cfs)

S T E P 4

Surcharge Height

H3 = a * Qp3 ^ b
H3 = 5.99 (ft.)

Diff.Volume,STOR3,

E1 = H3 + H2
E1 = 139.99 (cfs)
Volume = Exp((E1-m)/n)
Volume = 1780.276 (ac-ft)

STOR3 = Volume - Volume2
STOR3 = 1625.506 (ac-ft)
or
STOR3 = .02 (in.)

NEW STO AVE.= (OLD STO.AVE. + STOR3) / 2
NEW STO.AVE.= .02 (in.)

Qp4 = Qp1 * (1 - NEW STO.AVE. / R)
Qp4 = 46099 (cfs)

Surcharge Height

H4 = a * Qp4 ^ b
H4 = 5.99 (ft.)

E2 = H4 + H2
E2 = 139.99 (ft.)

C H E K I N G :

E3 - E2 = 0 (ft.)

R E S U L T S :

AVERAGED DISCHARGE= 46099 (cfs)

WATER SURFACE ELEV.= 139.99 (ft.)

SURCHARGE HEIGHT = 5.99 (ft.)

CREST ELEV. OF THE DAM:
Ec= 142.21 (ft.)

VOLUME AT DAM CREST ELEV.:
Vc = 4379.859 (ac-ft)

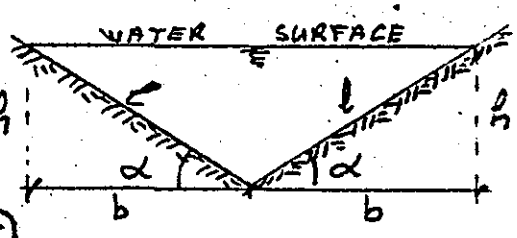
VOLUME AT MAX.WATER SURFACE ELEV

Vw = 1780.278 (ac-ft)

Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 11 of 23
Subject WOODLAND DAM By T. OTOVA Date 09-10-81
HYDROLOGY - HYDRAULICS Ckd. Rev.

DERIVATION OF STAGE - DISCHARGE RELATIONSHIP

The flood plain is assumed to have a triangular shape, for simplification reason.



Area, $A = \frac{h \times b}{2} \times 2 \qquad A = h \times b$

$\frac{h}{b} = \tan\alpha \qquad b = \frac{h}{\tan\alpha}$

$$\boxed{A = \frac{h^2}{\tan\alpha}} \quad (I)$$

Wetted Parameter, W,

$W = 2l \qquad \frac{b}{l} = \cos\alpha \qquad l = \frac{b}{\cos\alpha}$

$$\boxed{W = \frac{2b}{\cos\alpha}} \quad \cdots (II)$$

Hydraulic Radius, R,

$$R = \frac{A}{W} = \frac{bh}{2\frac{b}{\cos\alpha}} = \frac{h}{2} \times \cos\alpha$$

$$\boxed{R = \frac{h\cos\alpha}{2}} \quad \cdots (III)$$

Manning's Formula, $Q = \frac{1.49 \times A \times R^{2/3} \times S^{1/2}}{n}$

S is the channel slope
n is the roughness wefficient

By substituding in the formula A, R by the formulas I and II,

$$Q = \frac{1.49}{n} \times \frac{h^2}{\tan\alpha} \times \left(\frac{h \times \cos\alpha}{2}\right)^{2/3} \times S^{1/2} = \frac{1.49}{n} \times \frac{S^{1/2}}{\tan\alpha} \times \frac{(\cos\alpha)^{2/3}}{2^{2/3}} \times h^{8/3}$$

then, $$h = \left[\frac{n \times \tan\alpha \times 2^{2/3}}{1.49 \times (\cos\alpha)^{2/3} \times S^{1/2}} \times Q\right]^{3/8}$$

or, $$\boxed{h = \frac{1.066 \times n \times \tan\alpha}{} \times Q} \quad \cdots (IV)$$

Client CORPS OF ENGINEERS Job No. 1345-072 Sheet 12 of 13
Subject WOODLAND DAM By T. OTOVA Date 09-10-81
HYDROLOGY — HYDRAULICS Ckd. Rev.

WOODLAND RES.
DAM FAILURE ANALYSES

These calculations are performed according to the RULE OF THUMB procedures of the Corps of Engineers

The breach discharge:
Qp1 = 8/27 * Wb * g^0.5 * Yo^3/2

Where,

Yo is the height of the breach (from river bed to the max. pool level)

Wb is 35% of the length of the dam, or Wb = .35 * Wd

g is the acceleration of the gravity (32.2 ft/sec^2)

Yo = 39 (ft)

Wd = 1380 (ft)

Wb = 483 (ft)

From above equation,
Qp1 = 197787 (cfs)

The natural channel cross sections are simplyfied as triangular cross sections

The stage-discharge relationship becomes as,

h = [1.068 * n * Tan(a) * Q / Cos(a)^2/3 / S^.5]^3/8 ....(I)

Where,

Q = Discharge (cfs)
a = Side slope angle (deg)
S = Channel slope

The cross section Area:

A = h^2 / Tan(a) ....(II)

The Volume of the Reservoir,
V = 1780.278 (ac-ft)
or,
V = 77548909.68 (cub-ft)

Client CORPS OF ENGINEERS Job No. 1345-077 Sheet 13 of 13
Subject WOODLAND DAM By T.OTOVA Date 09-10-81
HYDROLOGY - HYDRAULICS Ckd. Rev.

R E A C H (1) CALCULATIONS

Test flood discharge:
Qt = 46100 (cfs)

a = 1.84 (deg.)
S = .001
n = .05
L = 50 (ft)

From Formula (I),

Prefailure height,

h1 = 18.8 (ft)

From Formula (II) ,

A1 = 11011 (sq.ft.)

Q = Qp1 + Qt

From Formula (I),
Total Height,
h = 35.1 (ft)

From Formula (II),
Total Area,
A = 38410 (sq-ft)

Residual Area,
A2 = A - A1
A2 = 27399 (sq-ft)

Residual Volume,

V1 = L * A2

V1 = 1369961 (cub-ft)

Qp2 = Qp1 * (1 - V1 / V)

Qp2 = 194293 (cfs)

From Formula (I),

Q=Qp2+Qt

Q = 240393 (cfs)

h = 34 (ft)

From Formula (II),

A = 37996 (ft)

Residual Area,

A2 = A - A1

A2 = 26985 (ft)

V2 = A2 * L

V2 = 1349288 (cub-ft)

Vave = (V1 + V2) / 2

Vave = 1359625 (cub-ft)

Qp2 = Qp1 * (1 - Vave / V)

Qp2 = 194319 (cfs)

From Formula (I),

Q = Qp2 + Qt

h2 = 34.9 (ft)

RESULTS :

1.) Prefailure Height = 18.8 (ft)

2.) Postfailure Height = 34.9 (ft)

3.) Breach Discharge = 194319 (cfs)

4.) Reach Length = 50 (ft)